PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION

ENGINEERING LIBRARY NOV 18 1920 UNIV. OF MICH.


# ENGINEERING:

## An Illustrated Weekly Journal.

*EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.*

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CX.—No. 2861.] *LONDON: FRIDAY, OCTOBER 29, 1920.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...1s 2d. BY FOREIGN POST 1s. 5d.



**Rubber** MANUFACTURERS

**Packings** "Redstone" "Bluestone"

GUTTA PERCHA & RUBBER, LIMITED.,

Toronto - - Canada. 8510

**A. G. Mumford, Ltd.,**

CULVER STREET WORKS, COLCHESTER.

ON ADMIRALTY AND WAR OFFICE LISTS.

ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.

See Advertisement, pages 33 and 100, last week.

PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS.

And Auxiliary Machinery as supplied to the Admiralty. 2179

**John H. Wilson & Co., Ltd.**

**Birkenhead.**

See Illustrated Advertisement Page 135, Oct. 8.

**Locomotive Shunting Cranes**

**Steam and Electric Cranes,**

EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS, SHIPS WINDLASSES, WINCHES, and DECK MACHINERY.

8369

LISTS OF STANDARD SIZES ON APPLICATION.

London Office: 15, VICTORIA STREET, S.W. 1.

**Craig & Donald Ltd., Machine**

TOOL MAKERS, JOHNSTONE, near Glasgow. For class of Machine Tools see our Illustrated Advertisement every alternate week. 1356

CHANTIERS & ATELIERS

**Augustin Normand**

67, rue de Perrey—LE HAVRE (France).

Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats. NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines. 2390

**Electric Lifts** (UP TO 35 TONS.)

S. H. HEYWOOD & CO., LTD., REDDISH. 8143

**Steam Hammers** (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS.

DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH. 8329

**Brett's Patent Lifter Co.** LIMITED.

**Hammers, Presses, Furnaces,**

COVENTRY. 610

**Bever, Dorling & Co., Ltd.,**

BRADFORD.

HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1906

**Cranes.—Electric, Steam,**

HYDRAULIC and HAND, of all types and sizes.

GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 8267

Telegrams—"Cylinders," Birmingham.

**Weldless-Steel Tubes**

for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work Boring Rods, &c.

TUBES LIMITED, BIRMINGHAM. 8179

**Yarrow & Co., Ltd.,**

SHIPBUILDERS AND ENGINEERS, GLASGOW.

SPEEDS UP TO 45 MILES AN HOUR.

PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.

**Repairs on Pacific Coast**

by YARROWS, LIMITED, Victoria, British Columbia. 8708

SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

**Campbells & Hunter, Ltd.**

SPECIALISTS IN

**Drillers & Boring Machinery**

for Engine Works and Boiler Shops.

DOLPHIN FOUNDRY, LEEDS. 4547

**Yachts, Launches or Barges**

Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551

VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

**Cochran** MULTITUBULAR AND CROSS-TUBE TYPES.

**Boilers.**

See page 17, Oct. 22. 8308

**Electric Cranes.**

8143

S. H. HEYWOOD & CO., LTD., REDDISH.

FOR

**Drop Forgings**

write

GARTSHERRIN ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 8519

THE GLASGOW ROLLING STOCK AND PLANT WORKS

**Hurst, Nelson & Co., Ltd.,**

Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.

Makers of WHEELS and AXLES, RAILWAY PLANT. FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS. PRESSED STEEL WORK OF ALL KINDS.

Registered Office and Chief Works: Motherwell. London Office: 14, Leadenhall Street, E.C. Od 3382

**Tank Locomotives**

Specification and Workmanship equal to Main Line Locomotives.

R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 8308

**Excavators.**

FROM 50 TO 600 YARDS PER HOUR.

**D. Whitaker,**

1, UNION STREET, LEICESTER. 7065

**"Spencer-Hopwood" Patent**

Sole Makers:

**Boilers.**

W. H. SPENCER & CO., HITCHIN, HERTS.

See page 18, Oct. 22. 8421

**The Cambridge and Paul Instrument Co., Ltd.,**

Manufacturers of Mechanical and Electrical Instruments of Precision.

*Head Office and Showrooms:*

45, GROSVENOR PLACE, LONDON, S.W. 1.

Works: London and Cambridge. 8194

GOLD MEDAL—INVENTIONS EXHIBITION—AWARDED.

**Duckham's Patent Suspended**

WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. London, E.—Hydraulic Cranes, Grain Elevators, &c.

See Illus. Advt. last week, page 15. 8002

FOR

**Railway Wagon Couplings**

and GENERAL SMITHY WORK, write

WELDLESS CHAINS, LTD., Coatbridge. 8184

Iron and Steel

**Tubes and Fittings.**

8746

**The Scottish Tube Co., Ltd.,**

HEAD OFFICE: 34, Robertson Street, Glasgow.

See Advertisement page 98.

**Royles Limited,**

ENGINEERS, IRLAM, MANCHESTER.

FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } Row's Patents.

Merrill's Patent TWIN STRAINERS for Pump Suctions.

SYPHONIA STEAM TRAPS, REDUCING VALVES High-class GUNMETAL STEAM FITTINGS, WATER SOFTENING and FILTERING. 8733

**Tubes and Fittings,**

IRON AND STEEL

**Stewarts and Lloyd's, Ltd.,**

41, OSWALD ST., GLASGOW.

BROAD STREET CHAMBERS, BIRMINGHAM; and LONDON OFFICE—

WINCHESTER HOUSE, OLD BROAD STREET, E.C.

LONDON WAREHOUSE—167, UPR. THAMES ST., E.C.

LIVERPOOL WAREHOUSE—63, PARADISE ST.

MANCHESTER WAREHOUSE—34, DEANSGATE.

CARDIFF WAREHOUSE—132, BUTE ST.

BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPCOTE STREET.

See Advertisement page 38. 8187

**Die Finished Castings**

ensure rapid production and reduce prime cost by eliminating machining operations. Write for Illustrations to SPARKLETS AND GENERAL Mfg. Co., Ltd., Edmonton, London, N. 18. 7896

FLEXIBLE, NON-RUSTING

**Metallic Hose-Covering**

to protect & strengthen tubing for all pressures & purposes. As supplied for H.M. Govt. SPARKLETS & GENERAL MFG. CO., Ltd., Edmonton, N.9.

**Locomotive Traversers**

(ELECTRIC). 8143

S. H. HEYWOOD & CO., LTD., REDDISH.

**Union Transit Company,**

FREIGHT CONTRACTORS. SHIPPING AGENTS. INSURANCE BROKERS.

WAREHOUSE KEEPERS and DISTRIBUTING AGENTS.

We solicit a trial shipment. 8689

Chief Office: 381, ARGYLE STREET, GLASGOW Cables and Telegrams: "Transit, Glasgow."

**The Glasgow Railway Engineering Company,**

GOVAN, GLASGOW. LTD.,

London Office—12, Victoria Street, S.W.

MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES, CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 8237

Patent

**See's** Hydro-Pneumatic **Ash Ejector.**

Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4886

**Diesel Driven Generators,**

400-500 Kw., D.C., 500 or 250 Volts, 220 R.P.M., in excellent condition. Low price.

Engines and Dynamos could be sold separately.

Also TWO 500 Kw. Parsons TURBINES, 230-250 Volts, D.C. (in series 460-500 volts), complete with Spare Armature and Condenser.

Exhaust TURBINE SET, Willans-H.C.C., 300 Kw., 440/500 Volts. Complete with Condenser, Pumps, &c.

JENNINGS, West Walls, Newcastle-on-Tyne. 8868

**For Sale.—**

MOTOR-DRIVEN PLANING MACHINE,

To plane 30 ft. by 20 ft. by 10 ft., four Tool Boxes. Condition as new. Makers, Buckton & Co.

Price and particulars from—

MURRAY, McVINNIN & CO., LTD., Mavisbank Quay, Glasgow. 8749

**E. J. Davis, M.I.Mech.E.,**

Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

**P. & W. MacLellan, Limited,**

CLUTHA WORKS, GLASGOW.

MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.

RAILWAY IRONWORK, BRIDGES, ROOFING, &c.

Chief Offices: 120, Trongate, GLASGOW. Od 8547

Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W. 1.

**Yarrow Patent**

**Water-Tube Boilers.**

8709

MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.

YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

**John Bellamy Limited,**

MILLWALL, LONDON, E.

GENERAL CONSTRUCTIONAL ENGINEERS. 1916

**Boilers, Tanks & Mooring Buoys**

STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK.

**Hurst, Nelson & Co., Ltd.**

THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL, Od 3382

**Head, Wrightson & Co.,**

LIMITED.

See Advertisement page 54, Oct. 22. 8402

**Taylor & Challen Presses**

8196

TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM.

See Full Page Advertisement, Oct. 15.

**Matthew Paul & Co., Ltd.**

**Dumbarton,** 8883

LEVENFORD WORKS.

See Full Page Advt., page 89, Oct. 15.

**Newcastle Shipbuilding Co.,**

LIMITED, HEBBURN-ON-TYNE.

Telegraphic Address: "Watertight, Hebburn."

Telephones: Hebburn 53, 54, 55, 56.

BUILDERS OF PASSENGER, CARGO AND OIL TANK STEAMERS.

Licensees to build under the ISHERWOOD SYSTEM.

Capacity of Shipyard: 8443

10 BUILDING BERTHS UP TO 850 feet.

RIVER FRONTAGE, 1800 feet.

**Electric Transporters.**

S. H. HEYWOOD & CO., LTD., 8143 REDDISH.

AERIAL ROPEWAYS, CABLEWAYS, CRANES.

**Steel Castings.**

8161

See displayed advertisement every fourth week.

JOHN M. HENDERSON & CO., ABERDEEN.

ON ADMIRALTY LIST.

**John Kirkaldy, Ltd.,**

London Office: 101, LEADENHALL ST., E.C.3.

Works: BURDETT MILL, near HARLOW, ESSEX.

Makers of

Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 8690

**Aluminium**

8291

THE BRITISH ALUMINIUM CO., LTD., 109, Queen Victoria St., London, E.C. 4.

See Advt. Page 120, Oct. 22.

**Steam Hammers**
**Power Hammers**
**Steam and Friction**
**Drop Stamps.**

**B. & S. Massey, Ltd.,** 8233 MANCHESTER.

## The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 8443

## Inst.C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "(f)" embraces 25 years' professional experience. Address, 7434, Offices of Engineering.

## Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all Engineering Exams. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. Trevor W. Phillips, B.Sc.(Hons.). Assoc.M.Inst.C.E., M.R.S.I., etc., 8–10, Trafford Chambers, 56, South John Street, Liverpool. 8423

## Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. Knowles, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., Prepares Candidates personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 8605

## Penningtons, University

Tutors, 264, Oxford Road, Manchester. Estab. 1876. Postal Courses for all Engineering Exams. Enrol now for I.C.E. and I.M.E. Courses. 96 per cent. passed last Exams. 8601

## Freyn Brassert & Company,

Engineers, of Chicago, with Offices at 39, Victoria Street, Westminster, London, have been AWARDED the CONTRACT for the NEW BLAST FURNACE PLANT of the Royal Dutch Blast Furnace & Steel Works concern, at Ymuiden, Holland. K 491


## TENDERS.

India Office,
Whitehall,
28th October, 1920.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

## Tenders from such Persons as may be willing to SUPPLY—

SCREW COUPLINGS.
PLATES, COPPER.
AXLEBORES.
SPRINGS, Laminated &c. } (1)

LOCOMOTIVE TANK ENGINES,
2 ft. gauge. (2).

The Conditions of Contract may be obtained on application to the Director General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that office by Two o'clock p.m. on Friday the 12th November, 1920, for No. 1, and on Tuesday, the 16th November, 1920, for No. 2, after which times respectively no Tender will be received.

G. H. COLLIER,
Director General of Stores.
K 480

MIDLAND GREAT WESTERN RAILWAY OF IRELAND.

CONTRACTS FOR 1921.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

## Tenders for the Supply of the

undermentioned STORES. The Contracts to commence from the 1st of January next, and terminate on the 31st of December, 1921.

| | No. of Form. | | No. of Form. |
|---|---|---|---|
| Asbestos & Packing | 1 | Oils | 26 |
| Barrows and Trucks | 2 | Paints, Colours and Wallpaper | 27 |
| Baskets and Mats | 3 | Ropes and Canvas | 28 |
| Brushes, Brooms, &c. | 4 | Rail Fastenings, iron | 29 |
| Brass Fittings for Gas and Water | 5 | ,, ,, steel | 30 |
| Bolts, Nuts & Rivets | 6 | Screws, Split Pins, Nails, &c. | 31 |
| Bricks, Slates, Earthenware Pipe, &c. | 7 | Sheet Tin, Lead, Gun Barrel, &c. | 32 |
| Chain | 8 | Steel Tyres, Axles and Plates | 33 |
| Cement | 9 | Steel & Copper Tubes, Copper Plates and Ingots | 34 |
| Candles and Soap | 10 | Steel Castings | 35 |
| Carriage Fittings | 11 | Staffordshire Iron, Wire, &c. | 36 |
| do. Trimmings | 12 | Springs, Steel, and Files | 37 |
| Creosote Oil | 13 | Soft Goods | 38 |
| Drysalteries | 14 | Timber, &c. | 39 |
| Fog Signals | 15 | Tools | 40 |
| Farm Produce Boxes | 15A | Tool & Barrow Shafts | 41 |
| Glass | 16 | Varnishes | 42 |
| Grease | 17 | Wagon Covers and Tarpaulins | 43 |
| Gas Mantles, &c. | 18 | Waste and Wicking | 44 |
| Iron & Steel Forgings | 19 | Yorkshire Iron | 45 |
| Iron Castings | 20 | | |
| India Rubber Goods | 21 | | |
| Lime | 22 | | |
| Leather and Belting | 23 | | |
| Lamps and Tinware | 24 | | |
| Locks, Rainwater Goods & Hardware | 25 | | |

Forms of Tender can be obtained, on payment of 6d. each, from the STOREKEEPER, GENERAL STORES DEPARTMENT, BROADSTONE STATION, DUBLIN. *Please do not send Stamps.*

Patterns and Samples can be inspected at the same place on and after 3rd prox., between the hours of Ten a.m. and Four p.m. (Saturdays, Ten a.m. to Twelve noon).

Contractors cannot be allowed to tender to supply goods to their own patterns, nor can the Company's patterns be sent away for inspection.

The Directors will not consider any Tender unless furnished on the Company's forms; nor any Tender in which any alteration of the form has been made.

The Tenders to be sent in by post, sealed and endorsed on the envelope, "Tender for Stores, Form No. ——," and addressed to "The Chairman, Broadstone Station, Dublin," so as to reach him on or before 10 a.m. on the 10th November.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order,
PERCY A. HAY,
Secretary.

Broadstone Station, Dublin,
October, 1920. K 435

METROPOLITAN BOROUGH OF LEWISHAM.

WEIGHBRIDGE.

The COUNCIL are prepared to receive

## Tenders for the Supply,

DELIVERY and ERECTION of a 20 ton WEIGHBRIDGE capable of weighing motor lorries at their Depot at Molesworth Street, Lewisham, on foundations prepared by the Council.

The Contractor to submit drawings and specification with their Tender, to state the approximate time within which the work would be completed, and also the amount they are prepared to allow for the existing weighbridge.

The Form of Contract may be seen and copies of the Form of Tender obtained free of charge at the Town Hall, Catford (Surveyor's Department).

The Tenders, which must be on the Forms supplied by the Council, to be enclosed in an envelope, sealed and endorsed "Tender for Weighbridge," and be delivered by Tuesday, 16th November, 1920, at the Town Hall, Catford, and placed in the box there provided for the purpose.

The Works must be proceeded with immediately on receipt of the Borough Surveyor's order.

A declaration to the effect that the Contractor will pay such rates of wages and observe such hours of labour as are recognised by Associations of Employers and Trade Unions must be signed by each person tendering.

The Council do not bind themselves to accept the lowest or any Tender.

JOHN T. DUFF,
Deputy Town Clerk.

Town Hall,
Catford, S.E. 6.
25th October, 1920. K 438

GREAT NORTHERN RAILWAY COMPANY (IRELAND.)

CONTRACTS FOR GENERAL STORES.

The Directors are prepared to receive

## Tenders for the Supply of the

undermentioned STORES for Twelve Months, from the 1st January, 1921.

| | No. of Form. | | No. of Form. |
|---|---|---|---|
| Axles and Tyres (Steel) | 1 | Iron Plates, Bars, Angles, Tees, and Forgings (best Staffordshire and Yorkshire) | 27 |
| Baskets, Brooms, Brushes, Mats, and Sponges | 2 | Lamps (Oil) and Brass Carriage Fittings, Oiler Pads, and Enamelled Iron Plates | 28 |
| Bolts and Nuts, Studs, Pins, Rivets, and Washers | 3 | Lead (ground in oil and dry), Sheet, &c. | 29 |
| Boxes, Farm and Market Produce | 4 | Leather and Leather Goods, and Balata Belting | 30 |
| Brass and Copper Sheets, Plates, Tubes, and Wire, Block Tin, Zinc, Spelter, and Patent Metal | 5 | Nails | 31 |
| Buckets, Oil Cans, Zinc Sheets, Galvanised Iron Sheets, Emery, &c. | 6 | Oil Creosote | 39 |
| Buffers and Axle Guards for Carriages and Wagons, Wagon Hinges, Barrow Frames, &c. | 7 | Oilskin Suits | 32A |
| Canvas | 8 | Oils (Burning, Lubricating, &c.) | 33 |
| Castings (Ordinary Iron) Firebars, Forgings, Cruciblies, Cylinders, and Buffer Stops | 9 | Plates (Steel Boiler), Steel Forgings, Fish Plate Liners, Cast Steel Engine and Tender Wheel Centres, Roof Bars, and Mild Steel Plates, Bars, Angles, Tees, and Channels | 34 |
| Cement, Plaster of Paris, Slate, Glazed Ware Pipes, Fire Bricks, Tiles, &c. | 10 | Rope, Twine, Flax, and Hemp Gaskin | 35 |
| Chain | 11 | Screws (Iron and Brass), Split Pins, &c. | 36 |
| Colours, &c. (ground in oil and dry) and Hall's Distemper, Wall Paper, &c. | 12 | Springs for Engines, Carriages, Wagons, &c. | 38 |
| Drysalteries | 13 | Tin Plates | 39 |
| Electrical Fittings, Lamps, &c. | 14 | Timber, White American Oak, Scantlings, St. John's Spruce Plank, Logs, Planks, Boards, Mouldings, Sheetings, &c. | 40 |
| Electric Cable and Wire | 15 | Transfers (Carriage, &c.) | 41 |
| Explosives, Fog Signals, and Carbide of Calcium for acetylene gas lighting | 17 | Tools (Edge), Saws, Files, Tool Steel, Carriage Keys, Hammers, Shovels, Spades, &c. | 42 |
| Fastenings, Permanent Way | 18 | Tubes and Fittings (Iron), Wire, Wire-Work, Panel Pins, Staples, and Point Rodding | 43 |
| Fittings (Brass) for Gas and Water, Gas Burners, Gun-metal Steam Unions, Rain Water Pipes, &c. | 19 | Tubes (Steel—Galvanized), Cold Drawn, Weldless for Boilers | 44 |
| Gauges, Steam and Vacuum Brake | 22 | Upholstery for Carriages, Curled Hair, Blinds, Rugs, Linoleums, Tape, and Soft Goods | 45 |
| Glass | 23 | Varnishes, Enamel, Black Lacquer, and Sheet Dressing Composition | 46 |
| Hammer, &c., Handles, Barrows, Oak Keys, Loading Boards and Scotches | 24 | Waste (Cotton), Wick, Sponge Cloths, &c. | 47 |
| Hinges (Wrought Iron and Brass), Locks, and Keys, Hardware (Iron and Brass), Closet Basins and Seats, &c. | 25 | | |
| Indiarubber Goods, Loco. Packing, Asbestos, &c. | 26 | | |

Tenders must be for the supply of Goods in accordance with the samples, which may be seen at the General Stores Depot, Dundalk, between the hours of Ten a.m. and Four p.m. on each week day except Saturdays.

Tenders made out on Forms obtainable from the SECRETARY on payment of One Shilling each, should be sent in under sealed cover endorsed "Tender for Stores," so as to reach the undersigned, not later than Ten a.m. on the 10th November, 1920.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station,
Dublin, 26th October, 1920. K 449

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY.

OLD MATERIALS FOR SALE.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

## Tenders for the Purchase of

OLD MATERIALS.

Form of Tender, giving full particulars, can be obtained on application to the Storekeeper, General Stores Department, Broadstone Station, Dublin.

Tenders must be posted in time to be received at Broadstone on Tuesday morning, 9th November, 1920.

By Order, PERCY A. HAY,
Secretary.

Broadstone Station, Dublin,
25th October, 1920. K 426

VICTORIAN RAILWAYS.

THE GOVERNMENT OF THE STATE OF VICTORIA, AUSTRALIA, invites

## Tenders for Contract

33419, the SUPPLY, DELIVERY, ERECTION and TESTING, or, alternatively, the SUPPLY and DELIVERY ONLY of ELECTRIC FURNACE AND EQUIPMENT, and, alternatively, for the SUPPLY and DELIVERY of EQUIPMENT and DRAWINGS for ELECTRIC FURNACE, for Newport Workshops.

Specification, Conditions of Contract, and Forms of Tender, may be obtained at the Offices of the Consulting Engineers, John Coates & Co., Ltd., Victoria House, Melbourne Place, Strand, London, W.C. 2.

Tenders must be addressed to The Secretary, Victorian Railways, Melbourne, Australia, marked "Tender for Electric Furnace and Equipment," and mailed in time to reach Melbourne on or before eleven a.m. on Wednesday, 19th January, 1921.

A preliminary deposit equal to 1½ per cent. of the total amount of the Tender must accompany each Tender.

The Government of Victoria does not bind itself to accept the lowest or any Tender. K 470

(Signed) PETER McBRIDE,
Agent General for Victoria.

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD.
(Plant and Machinery Section).

## For Sale By Public Tender,

Closing date NOVEMBER 13TH, AT 10 A.M.

ACETYLENE WELDING PLANT as follows:—

No. M.K.16638.—One Acetylene Welding Plant complete with generator container, carbide bins and box of spares.

List of Accessories issued with Plant Acetylene Welding, Watchman No. 101 Complete.

Blow-pipe Set with seven interchangeable nozzles to use from 1-2 ft. to 24 ft. Acetylene per hour. Complete in Wood case with full instructions (Set 1).

Oxygen Pressure Regulator with pipe pressure gauge (No. 1).

Goggles Welding (pairs 1).
20 ft. Lengths ½ in. 3 ply best quality Hose (No. 2).
Welding Flux for Cast Iron and Brass (1 lb. of each).
Welding Flux Aluminium (1 lb. of each).
One Spare Carbide gauge (No. 1).
Oxygen Cylinder Key (1).
⅛ in. Swedish Iron Feed Wire (7 lbs.).
7/32 in. Swedish Iron Feed Wire (3 lbs.).
⅛ in. to 7/32 in. Aluminium (½ lb. of each).
Ferro Silicon Cast Sticks, ½ in. dia., packed in Stout deal case with straps, hinged lid (1 doz.).
Two cwt. Carbide Bin, 22 swg. steel sheets galvanised with gas tight iron or brass cover (No. 1).

No. M.K.16640.—One Acetylene Welding Plant complete with generator container, carbide bins, and box of spares.

List of Accessories issued with Plant Acetylene Welding, Watchman No. 101 Complete.

Blow-pipe Set with seven interchangeable nozzles to use from 1-2 ft. to 24 ft. Acetylene per hour. Complete in wood case with full instructions (Set 1).

Oxygen pressure regulator with pipe pressure gauge (No. 1).

Goggles Welding (pairs 1).
20 ft. Lengths ½ in. 3 ply best quality Hose (No. 2).
Welding Flux for Cast Iron and Brass (1 lb. of each).
Welding Flux Aluminium (1 lb. of each).
Spare Carbide Gauge (No. 1).
Oxygen Cylinder Key (No. 1).
⅛ in. Swedish Iron Feed Wire (7 lbs.).
7/32 in. Swedish Iron Feed Wire (3 lbs.).
⅛ in. and 7/32 in. Aluminium (½ lb. of each).
Ferro Silicon Cast Sticks, ½ in. dia., packed in stout deal case with straps hinged lid (1 doz.).
Two cwt. Carbide Bin, 22 swg. steel sheet galvanised with gas tight iron or brass cover (No. 1).

No. M.K.16641.—One Acetylene Welding Plant, complete with generator container, carbide bins and box of spares.

List of Accessories issued with Plant Acetylene Welding, Watchman 101 complete.

Blow-pipe Set with seven interchangeable nozzles to use from 1-2 ft. to 24 ft. Acetylene per hour. Complete in wood case with full instructions (Set 1).

Oxygen Pressure Regulator with pipe pressure gauge (No. 1).

Goggles Welding (pairs 1).
20 ft. Lengths ½ in. 3 ply best quality Hose (No. 2).
Welding Flux for Cast Iron and Brass (1 lb. of each).
Welding Flux Aluminium (1 lb. of each).
Spare Carbide Gauge (No. 1).
Oxygen Cylinder Key (1).
⅛ in. Swedish Iron Feed Wire (7 lbs.).
7/32 in. Swedish Iron Feed Wire (3 lbs.).
⅛ in. and 7/32 in. Aluminium (½ lb. of each).
Ferro Silicon Cast Sticks, ½ in. dia., packed in stout deal case with straps hinged lid (1 doz.).
Two cwt. Carbide Bin, 22 swg. steel sheet galvanised with gas tight iron or brass cover (No. 1).

Permits to view and Tender Forms to be obtained upon application to:—
THE CONTROLLER,
D.B.I.E.,
Charing Cross Huts,
Embankment,
(Sales Section). K 451

## APPOINTMENTS OPEN.


## Wanted for a Research

Association a TRAINED RESEARCHER, to undertake the investigation of the corrosion of non-ferrous metals and alloys, to be conducted in London. Salary £360 to £450 according to qualifications. Applications in writing, accompanied by three references to be sent to—
Mr. ALLEN B. MUNBY,
9, Old Square,
Lincoln's Inn, W.C. 2.
not later than November 22nd. K 439

CONTINUATION CLASSES.

THE EDUCATION AUTHORITY OF GLASGOW are prepared to consider

## Applications from Teachers

of ENGINEERING DRAWING (all stages), MATHEMATICS (higher stages), MECHANICS and ENGINEERING SCIENCE SUBJECTS.

There are no immediate vacancies but the names of the successful candidates will be placed on the reserve list and given appointments as vacancies occur during the session.

Forms of application can be obtained from the DIRECTOR OF EDUCATION, 129, Bath Street, Glasgow. K 440

UNION OF SOUTH AFRICA.

BREBNER SCHOOL, BLOEMFONTEIN.

## Wanted, an Assistant

MASTER for the BREBNER SCHOOL, Bloemfontein, Orange Free State, South Africa, to commence duties 19th January, 1921. Must be an Associate of the Royal College of Science, London, on the Engineering side, or a Bachelor of Science in Engineering of some recognised University, hold the Board of Education Parchment Certificate, England, or the Privy Council Certificate of Scotland, or a University Diploma in Education, or an equivalent Certificate.

He will be required to teach Mathematics and General Science in the day school and Machine Design, Construction and Drawing and the allied subjects, especially Mechanical Engineering and Mechanics, in the evening classes.

Experience in teaching essential.

Salary £360 per annum rising by annual increments of £20 per annum to £540 per annum, plus War Bonus, which at present for a married man is £123 per annum, plus about £120 per annum for evening class work.

If the successful applicant is prepared to enter into an agreement on his arrival in South Africa, to serve the Administration of the Orange Free State Province for a term of not less than three years, a refund of his passage money to Cape Town at First Class Intermediate (B 3 or B 4) or Second Class Mail (D 1) rate will be granted, on production of the usual receipts. A free railway warrant for First Class Ticket from Cape Town to Bloemfontein and a warrant for 300 lbs. excess luggage will be supplied.

Applications, in duplicate, stating age, academic and professional qualifications and length of teaching experience, with subjects taught, must reach the SECRETARY, Office of the High Commissioner for the Union of South Africa, 33, Victoria Street, London, S.W. 1, not later than 15th November, 1920. K 394

## Assistant Works Manager

WANTED, for high class machine tool works, 600 to 700 employees, Manchester district. Must be energetic and capable of taking full control and direction of all machining operations to obtain maximum output. State experience, qualifications and salary required.—Address, K 442, Offices of Engineering.

## Assistant Machine Shop

MANAGER REQUIRED for large Engineering works. Must have first-class experience in all latest machine tools and up-to-date methods for obtaining output. Plant to be controlled includes large variety and a big range in sizes of machine tools. Permanent post for progressive man.—Address, stating age, salary expected, also experience and qualifications, K 346, Offices of Engineering.

## Mill Manager.—Wanted, by

an Important Firm of Steel Manufacturers in the Midlands possessing several large rolling mills, a MILL MANAGER, with a thorough knowledge of the production of Blooms, Billets, Sheet Bars, Rounds and sections.—Address, in confidence, stating age, experience and salary required, K 331, Offices of Engineering.

## Melting Shop Manager

for steel works making wide range of products. Must have experience of special and alloy steels. Apply, stating full particulars.—Address, "MELTING," Wm. Porteous & Co., Advertising Agents, Glasgow K 496

## Applications are Invited

for APPOINTMENT as ASSISTANT MANAGER, Mathematical Instrument Office, Survey of India, Calcutta. Applicants should be between the ages of 24 and 35, must have optical experience in a modern scientific Instrument maker's factory, must thoroughly understand manufacture of surveying instruments and be conversant with machine shop practice and production. Engagement three to five years. Subject to renewal. Salary not less than Rs. 800 per mensem or more according to qualifications and experience.—Apply, REVENUE SECRETARY, India Office, London, S.W. 1. K 479

## Foundry Rates Fixer Wanted,

Yorkshire Area, would have the foreman's assistance in estimating rates, but would be responsible to the administration for the proper working of the premium bonus and piece-work system; only those with wide experience in a large iron foundry in a similar capacity need apply; good prospects to the right man. Age, wage and experience.—Address, K 453, Offices of Engineering.

## Wanted, by a Large Firm of

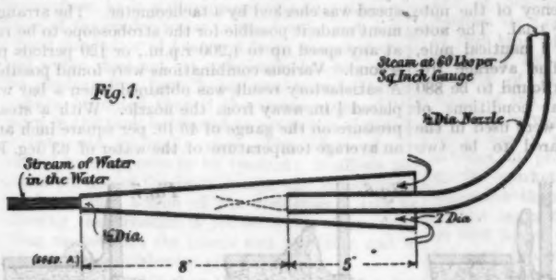
Hydraulic Engineers, a GENTLEMAN fully conversant with with Oil Mill Machinery, capable of superintending getting out of plans and estimates for same. Good salary and commission paid.—Address, stating experience and all details, K 445, Offices of Engineering.

# THE PRODUCTION OF SOUND UNDER WATER BY THE CONDENSATION OF STEAM.

By Gerald Stoney, F.R.S., and Telford Petrie, M.Sc.

The great war has undoubtedly increased our knowledge of practical acoustics. Problems affecting the location and detection of sound have had to be met and solved in the shortest possible time. The foundations of the subject, more especially on the theoretical side, had been well laid by Helmholtz, Poynting and Thomson, Lamb, and particularly Lord Rayleigh; but it was left to modern physicists such as Perrin and Walser in France and the two Braggs in England to bring listening gear, for both land and sea conditions, to a pitch of perfection that had not been previously reached or apparently been required. The sounds listened to were mostly those made by the enemy; but another phase of the subject was introduced when the detection of submerged bodies, such as submarines, was first considered. It was then thought necessary to produce a reliable and distinctive note or sound under water to be applied for this purpose. This was one of the problems to which the Lancashire Anti-Submarine Committee devoted itself; and the authors were deputed to investigate the possibilities of utilising steam for the production of such a note.

Fig. 1.




The production of musical notes under water does not in itself seem to have received much attention in the past. Where such attempts have been made they have been devised for ulterior purposes, such as the determination of the velocity of sound in liquids. In 1826 Colladon and Sturm* carried out their famous experiments to find the velocity of sound in water, and used a bell 70 cm. high and slightly less in diameter. This was immersed 1 m. in the Lake of Geneva and struck with a hammer. The sound was picked up 13,487 m. (9·6 nautical miles) away. In 1847 Wertheim used organ pipes for the same purpose, which were sounded by forcing a current of water through them.† Varying pressures of this water gave varying harmonics; considerable difficulty appeared in proportioning the pipes to sound under water. In 1853 Savart‡ produced sounds by the efflux of water from tubes, a method which was used by T. Martini§ in 1884 to determine the velocity of sound in various liquids. The tube is stopped at the bottom by a diaphragm with a small hole in it, but the note appears in the column of water in the tube and the tube does not appear to have been completely submerged itself.

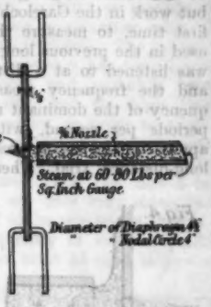
With regard to the siren, Poynting and Thomson say "as a matter of curiosity we must mention the fact that the siren sounds under water if entirely immersed and driven by a stream of water"‖—but this method did not fall within the scope of the present research, nor did the use of bells which have been developed for submarine telegraphy.

For their laboratory experiments a steam pipe, 1¼ in. internal diameter, was led vertically into a well below the condenser water measuring tanks in the authors' laboratory. This well could be flooded to a depth of 16 ft. or emptied at will. The investigation started in attempts to obtain a musical note by the simple expedient of blowing steam down into the water through the central hole of a thin diaphragm which closed the outer end of a short length of the 1¼-in. steam pipe. These attempts failed even when the short length was insulated from the main steam pipe by a length of rubber hose.

Another idea was suggested by Wertheim's method already referred to; but attempts to blow organ pipes under water by steam instead of by a current of water also failed. In connection with this, it is perhaps worth recording that by taking advantage of the partial vacuum caused by the condensing steam, and fitting a funnel to the nozzle long enough to allow all the steam to condense, as shown in Fig. 1, the authors subsequently succeeded in blowing an extemporised organ pipe under water with the pure jet of water that was obtained.

The short length of steam pipe used in the first experiments was then replaced by a receiver consisting of a cast-iron pipe 4 in. internal diameter and 2 ft. 10 in. long. The 1¼-in. steam pipe led into the top of this receiver and the lower end was closed by a series of diaphragms with central holes of various sizes. The whole was submerged to a depth of 6 ft. The results could hardly be called promising, but notes of between 100 and 150 periods were occasionally obtained. The frequency was measured by comparing the note in the air, as it came through the surface, with a tuning fork by ear. This method, which was only required for comparative purposes, was used throughout in the laboratory. From the fact that the notes sounded like a cow mooing, the apparatus was colloquially referred to as the "cow."

Fig. 2.



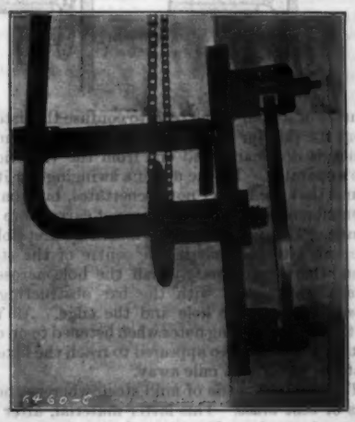



Fig. 3.

The steam pressures, as measured on a calibrated Bourdon pressure gauge near the stop valve, were so low that it was doubtful whether there was not a considerable quantity of water on the inside of the diaphragm. To test the effect of a water-borne diaphragm, another arrangement was tried. This simply consisted in playing a jet of condensing steam from a nozzle on to a diaphragm under water. A soft but distinct note of about 408 periods was obtained. In order to clear the steam as soon as it had impinged upon the diaphragm, the apparatus was then arranged so that a small hole in the centre of a vertical diaphragm allowed the condensing steam to impinge on its edges and escape on the far side. The note was distinct, and better than the previous one, but still too soft.

In all the methods attempted so far, the diaphragm had been clamped round its edges. The next step was taken to ascertain what the effect would be if the diaphragm were free to vibrate of itself, without transmitting its motion to the supporting apparatus. A convenient way of obtaining this was suggested by the well-known Chladni figures. In one of these a circular plate is supported on pointed corks under a nodal line and vibrated by rubbing a cord up and down against the side of a hole in the centre of the plate. Poynting and Thomson give the positions of such nodal circles when one, two or three nodes are present. For convenience in clamping, the largest of the three node circles was chosen, namely 0·804 D, and the diaphragm was supported on opposed knife edges at two points only on such a circle. The result was encouraging. A clear musical note about 600 frequency was obtained without difficulty when the conditions were adjusted as shown in Fig. 2. The repetition of this experiment in a larger tank appeared to establish the fact that the note was produced in the water, and not, as had hitherto seemed to be the case, in the steam or by the mechanical vibration of the apparatus as a whole.

A number of experiments were then made with this form of apparatus, and the following points were brought out:—

(*a*) A circular nozzle with parallel sides gave the most suitable form of jet of condensing steam.

(*b*) While notes could be obtained with various ratios of the diameter of this nozzle to the diameter of the central hole in the disc, a proportion of two to one was found to be very suitable.

(*c*) The distance between the end of the nozzle and the disc was an important factor, other conditions remaining the same.

(*d*) The proportions and material of the disc did not appear to have any controlling effect on the frequency of the note. This led to the unexpected conclusion that the note was not being produced by the vibration of the diaphragm, as had hitherto been supposed, but in some way by the condensing steam itself.

With the experience gained by the laboratory work already described, an apparatus was designed which is shown in Fig. 3. In this gear means were provided for adjusting the distance between the nozzle and the disc from above the water-level whilst the steam was on. Arrangements were made for carrying diaphragms of different sizes or discs of varying thicknesses, and also for changing the diameter of the nozzle. As a result of the laboratory work carried out with this apparatus, the following conclusions were reached:—

(*e*) To get a pure note the disc should be clamped on a nodal circle. This prevents the vibration from being transmitted to the remainder of the apparatus, to any appreciable extent. Subsequent work has shown that this point is not so important with small models (*e.g.*, ¼ in. or ⅛ in. diameter nozzles), but that the greater the energy produced the more necessary it is to take this precaution.

(*f*) The note, for any given pressure (and water temperature), was not continuous as the disc was run in towards the nozzle. A high note about 800 frequency was obtained at a certain point when the distance between the two was great, and was usually held as the disc was brought in, until a second point was reached where the note changed suddenly to one of a much lower frequency (about 200). It was occasionally possible to obtain a third note, of about 100 frequency, but all three notes were not always present with similar conditions.

(*g*) The size of the nozzle, and therefore the quantity of steam passing, affected the pitch of the notes. The smaller the nozzle, the higher the note, other things being equal.

(*h*) The pressure of the steam for any given size of nozzle correspondingly affected the frequency of the notes. The lower the pressure, the higher the note.

(*i*) As far as could be checked in the confined space of the laboratory, the maximum intensity of the note appeared on the steam or nozzle side of the disc.

The apparatus was then fitted to H.M.S.T. Leonora, stationed at the Admiralty Experimental

* "Annales de Chimie et de Physique," Series 2, vol. xxxvi, 1827.

† *Ibid.*, Series 3, vol. xxiii, 1848.

‡ *Comptes Rendus*, August, 1853.

§ "Atti del Reala Instituto," Veneto, Series 6, vol. iv appendix.

‖ "Text Book of Physics," Sound, 1899 Ed., bottom of page 37.

Station, Shandon, N.B., and the following trials were carried out: First of all a 4½-in. disc ¼ in. thick and ⅛ in. nozzle, was tried out at 300 yards, at three pressures corresponding to 105 lb., 75 lb. and 30 lb. per square inch on the gauge on deck. An independent observer listened from the shore with a general service hydrophone (G.S.H.). All notes were loud, the best one being at the medium steam pressure. The distance was then increased to 2 nautical miles. (Garelochhead to Shandon.) The listener was stationed in a dinghy off Shandon, and reported no appreciable diminution in sound at that range. Both the top and bottom notes at each pressure were heard. The boat was turned broadside on for this test, but the note was also heard whilst the boat was steaming away from the listener at 3 knots.

A ⅛-in. nozzle was then tried with a ¼-in. hole, in a 11¾ in. diameter (⅛ in. thick) diaphragm. It was soon established that the larger disc gave better results. The note was obtained over a longer range of pressures and was more piercing. The best note of all was with anywhere between 60 lb. and 75 lb. per square inch on the gauge with the diaphragm ⅜ in. away from the end of the nozzle. These results were then compared with a diaphragm 11¾ in. diameter, ¼ in. thick, with a ⅜-in. central hole, using a ⅜-in. diameter steam nozzle. The note was deeper and coarser, and the top note not so pure at short range. There seemed to be no advantage gained to make up for the extra steam used. (More than double the amount being required.)

As a result of these trials the following proportions were adopted for the subsequent work carried out with this form of apparatus (Fig. 3). A steel diaphragm, 11¾ in. diameter and ¼ in. thick, was clamped in two places on a nodal circle of 10½ in. diameter. It had a central hole of ⅜ in. diameter which was tapped with a fine thread. The nozzle used was ⅛ in. diameter with parallel sides. This apparatus gave a powerful note with a steam pressure of from 60 lb. to 75 lb. per square inch on the gauge on deck when the distance between the diaphragm and the end of the nozzle was ⅜ in. At first the nozzle was arranged pointing inwards towards the ship. It was next pointed forwards, and the ship steamed round in a circle 600 yards away. The note was heard all the time, even when the apparatus was on the other side of the ship, but was loudest when the ship was steering away from the listener. This corroborated the conclusion arrived at in the laboratory.

In further tests which were carried out in the Gareloch, the listener was stationed in a dinghy in 4 fathoms of water at the mouth of the loch, and the apparatus was tried out when the ship was 2 nautical miles away, *i.e.*, off Shandon, and 4 nautical miles away, *i.e.*, the full length of the loch; no appreciable diminution in sound was perceptible between half-way and the full distance. The medium pressure again gave the best results, and the note came through the noise of a motor launch 100 yards away from the listener. Up to the present the weather had been fine and the sea calm. The apparatus was next tried out in the Clyde in rough water. An independent observer picked up the note 3 nautical miles away, listening from a moving motor launch with a No. 2 "Lancashire Fish."

The longest range attempted was 11 nautical miles, when Lieutenant Dix, R.N.V.R., and Mr. Dobie, of Messrs. Cammell Laird, using a general service hydrophone, heard the note from a stationary motor launch so distinctly that the sound came out of the receiver as it lay on the cabin table. The sea was calm and the minimum depth of water between points was 16 fathoms. In this trial the ship was laying off Wemyss Point in the Clyde and the motor launch was just outside Little Cumbrae. In a test under bad weather conditions the ship was left alongside Gourock Pier and Mr. Redfern, a member of the Lancashire Anti-Submarine Committee, sailed towards Gareloch, listening with a No. 2 "Lancashire Fish." The conditions were bad, rough sea and shoals up to 1½ fathoms between. The note was heard distinctly all the time until the corner was turned into Gareloch. At 2 nautical miles Mr. Redfern found that he could compensate the note and gave the correct direction of Gourock from his cabin. The motor launch steamed out again and, laying off Helensborough, 4 nautical miles away, picked up the note again on a general service hydrophone.

The results of these sea trials pointed to the development of a convenient and cheap apparatus for producing a loud note under water, of considerable penetrating power. It was also found that a bar may be used instead of a circular diaphragm. Such a bar is conveniently damped and supported by a knife-edge at a nodal distance from the free end, the values of which may be obtained from Poynting and Thomson's "Sound," 1899, page 127. As used in the apparatus this distance is 0·226 L from the free end; but laboratory experiments have shown that other values would serve equally well. The hole should be placed at the point of maximum amplitude.

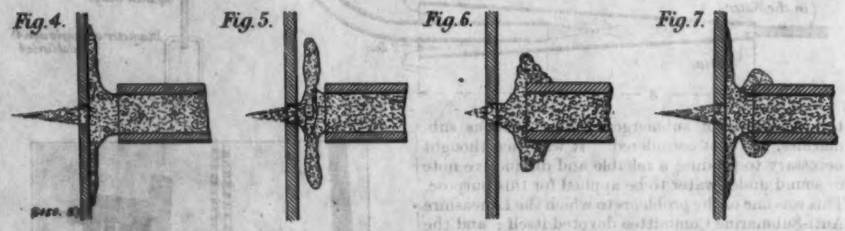
An opportunity occurred to carry out some further experiments at the Admiralty Experimental Station at Shandon. No long-range work was possible; but work in the Gareloch made it possible, for the first time, to measure the frequency of the note used in the previous long-distance trial. The note was listened to at a distance of 1 nautical mile, and the frequency measured. The average frequency of the dominant note was found to be 880 periods per second, with similar conditions of apparatus and steam pressure as were used in the long-distance trial. There appeared to be two sources of sound, which tend to confuse the listening from the ship (or near to); one from the steam jet, which is dominant, and one from the vibration of the apparatus. By the use of a swinging bar it was found that the former note penetrates, but that the vibration of the apparatus does not carry more than 1 mile. This point was determined by first holding the bar with the hole in the centre of the steam, then with approximately half the hole across the steam, and finally with the bar obstructing the steam between the hole and the edge. All three settings gave piercing notes when listened to on deck, but only the first two appeared to reach the listening station, just over 1 mile away.

The disc was made of mild steel, whereas the bar was of best brass. This latter material, after only 3 hours' running, showed marked signs of pitting, due to the force with which the steam bubbles collapsed; and it is obvious that the obstruction that carries the hole should be of hard material to withstand the wear of constant use. The mild steel disc had been used throughout the sea trials, and showed only the slightest signs of wear.

During the war, the research had been carried on with the object of achieving results; and, beyond noting points as they occurred, nothing was done to investigate the cause of a phenomenon that appeared to be new. The authors have since taken the opportunity of analysing the production of such a note under water by means of a condensing steam jet, under the auspices of the Manchester Municipal College of Technology.

The work that had already been done pointed so clearly to the production of the note in some way by the action of the condensing steam, rather than by the vibrations of the diaphragm or of the bar, that an attempt was made to ascertain the movements of the jet whilst a note was being produced. For this purpose a laboratory model* was used, which consisted of a straight-through nozzle, ⅛ in. in diameter, and a number of mild steel discs 4½ in. in diameter supported in one point only on a nodal circle 0·894 D., by an overhanging adjustable arm. A number of brass bars, 1 in. wide and 5 in. long, were also available. It was with these bars that various positions of the damping node had been tried out. The apparatus was placed in the centre of a tank, 26 in. square by 22 in. deep, which could be filled with clear water and emptied at will. The incoming feed-pipe delivered the water near the bottom, and an overflow drew it off from the surface. This made it possible for the water to be changed while the apparatus was running, so as to regulate the temperature and counteract the heating effect of the condensed steam. The steam pressure was read on a calibrated Bourdon gauge placed just above the tank, the steam supply being adjusted by hand on a stop valve.

Two 3½ in. diameter tubes with watertight glass windows were projected into the tank, one on each side of the nozzle, and a parallel beam of light was passed through. In this way the action of the steam could be watched under water. A stroboscope was used, consisting of a revolving disc with six slots, the width of which could be adjusted, driven by a controllable electric motor whose relative speed was checked by a tacheometer. The arrangement made it possible for the stroboscope to be run at any speed up to 1,200 r.p.m., or 120 periods per second. Various combinations were found possible. A satisfactory result was obtained when a bar was placed ⅛ in. away from the nozzle. With a steam pressure on the gauge of 45 lb. per square inch and an average temperature of the water of 63 deg. F.,




a note was produced whose frequency, compared with a tuning fork in the air, was 420. When the stroboscope was run at a speed of 1,040 r.p.m., corresponding to a frequency of 104, the movements of the condensing steam were clearly visible.

The steam is spread out like a mushroom by the flat surface, whilst the hotter central core escapes through the hole. The appearance is something like Fig. 4. The mushroom travels backwards away from the flat surface in the form of a ring or disc of condensing bubbles. The effect produced may appear like Fig. 5. This ring gradually collapses on and around the end of the nozzle, as in Fig. 6. The onward rush of steam from the nozzle forms another mushroom as the previous one is disappearing, and the process repeats itself (Fig. 7). In both 5 and 6 less steam comes through the hole to the other side of the flat surface. The flat surface acts as a condenser, and possibly as a sounding board, since the thicker it is, the sharper and clearer the note appears to be, within limits. A thin ring of steam nearest to the surface and furthest away from the nozzle condenses first, and allows the water to rush in from all sides. The result is that, momentarily, the flow of steam is checked, and the steam mushroom is forced backwards to collapse more gradually against the nozzle. The jet of steam through the hole shortens simultaneously with the retrogression of the mushroom ring. The collapse of this ringed wall automatically relieves the steam pressure, which rushes forward again out of the nozzle, and the cycle recommences. The musical note is apparently produced by a series of pulses or blows rather than by vibration or oscillation. Practically, it amounts to ringing water on water.

It is interesting to note how this theory accounts for the points observed and described in the first part of this paper.

The pitch is known to be higher: (*a*) The smaller the nozzle, or (*b*) the lower the pressure, *i.e.*, in both cases, the less the volume of steam flowing per second; (*c*) the further away the surface is from the nozzle. The less the volume of steam flowing, the smaller and more rapidly formed would be the steam bubbles and the mushroom heads. The periodicity

* This model is in the steam laboratory of the Manchester College of Technology.

of the note would therefore be higher. The longer the steam jet between the nozzle and the plate, the smaller in diameter it becomes before it impinges round the edge of the hole, and consequently the smaller the mushroom, as before. It is doubtful whether the ring travels back as far as the nozzle when producing these high notes; it probably collapses instead on the jet.

As a check on these conclusions, the stroboscope was removed, and only sufficient steam admitted to form a thin film against the flat surface. No note, of course, was formed, but the repulsion of this film backwards could be clearly seen. Osborne Reynolds once explained the singing of a kettle on the hob in a paper read before Section A of the British Association, at Oxford in 1894.* He pointed out that at about 10 deg. F. below boiling-point bubbles of steam are formed at the bottom of the kettle, which collapse suddenly with a sharp click when their ascension brings the steam into contact with the colder water above. This is apparently what is happening in the phenomenon just described. The flat surface, be it a diaphragm or a bar, takes the place of the colder water in the kettle, and, being a good conductor of heat and being surrounded by cold water, does not get sufficiently hot to prevent the condensation from being continuous. It may perhaps be noted that if the temperature of the water in the tank is allowed to get hotter the pitch of the note gradually rises. The effect of the central hole appears to be twofold; it allows the hotter portion of the jet to escape and so facilitates the immediate action of the condenser; and by relieving the pressure it prevents the steam from piling up between the nozzle and the plate and so defeating the mushroom effect.

It will be recalled that the authors found a bar made of best brass to be badly pitted or eroded after only 3 hours running in the sea. This points to comparatively large instantaneous pressures being set up by the collapse of the steam bubbles against the flat surface. In a paper read by the Hon. Sir Charles Parsons and Stanley S. Cook, on "Investigations into the Causes of Corrosion or Erosion of Propellers," before the Institution of Naval Architects on April 10, 1919,† a description is given of some water-siren experiments made by A. Q. Carnegie. When the fixed disc was made of soft cast brass, it eroded too badly for use in the siren after 10 minutes' running under a water pressure of 70 lb. per square inch. This effect is attributed to the momentum of each interrupted jet, causing momentarily a vacuous space to form behind it. The return action by concentration finally produces high velocities and pressures in a small volume of the fluid, giving rise—when the nucleus of pressure, or point at which collapse takes place, is located on the metal—to excessive water-hammering over a small area. In Appendix II of the same paper, Cook supposes that a rigid inner boundary to the fluid enclosing a vacuous space is suddenly removed; and he obtains an expression for the instantaneous pressure thus produced. His calculations and conclusions were confirmed by the late Lord Rayleigh in a paper to the Royal Society in August, 1917. Cook shows that the pressure on impact is independent of the size of spherical vortex cavities, and is only a function of the ratio of the initial to the final radii; so that very small cavities may cause erosion. For instance, when a spherical vortex cavity in the sea closes upon a central nucleus of one-tenth of the diameter of the original cavity, the blow upon this nucleus may reach 24·2 tons per square inch. If the diameter of the nucleus is one-hundredth of the diameter of the original cavity, the pressure may reach 765 tons per square inch.

Such instantaneous pressures, if present in the collapsing of steam bubbles against a flat surface, would account for the erosion noted in the brass bar. They would also point to the value of such a means of producing sound under water when long penetration is required, for energy is directly imparted to the surrounding water without the necessity of resonators or of any heavy mechanical apparatus such as is used in present submarine signalling gears.

In conclusion, the authors desire to express their indebtedness to the Admiralty for permission to refer to work which was carried out under their auspices, and also to thank the authorities of the Manchester Municipal College of Technology for enabling them to investigate the cause of what appears to be a new method of producing sounds under water.

* Experiments showing the boiling of water in an open tube at ordinary temperatures. Reprinted in "Scientific Papers," 1901, vol. ii., page 578 *et seq.*

† There is a reprint of this paper in ENGINEERING, April 18, 1919, page 518.

## RECENT DEVELOPMENTS OF ELECTRICALLY-HEATED "REVEL" BOILERS IN SWITZERLAND.

By E. G. CONSTAM-GUILL.

NEARLY 300 of the electrically heated "Revel" boilers, which are manufactured by the S. A. Escher Wyss and Co., of Zurich, have been delivered, and a number have been in operation for some years. Messrs. Escher Wyss are working, as regards this line of business, in close conjunction with the Ateliers de Construction Oerlikon. The adoption of this kind of steam generator has been greatly advanced by the present and probably future scarcity of fuel generally, and its high price. Many of the Swiss industries, in order to procure the necessary quantities of fuel, are forced to spend up to nearly as much as ten times the yearly amount of pre-war times. The fuel now-a-days on the market is also not only very much more expensive than it used to be previously, but it is at the same time frequently of inferior quality, so that larger quantities must be used to produce the same heating effect.

An actual example illustrating the present cost of fuel in Switzerland is furnished by a small cotton spinning mill which requires for one department about 2,000 kgs. (4,400 lb.) of low presure steam per day. Beechwood is burned on the existing boiler, the price of the fuel being 40 Swiss francs per cubic metre (35 cub. ft.) delivered on site. This price includes the cutting of the wood into blocks. The yearly consumption of wood amounts to 440 cub. m. (15,000 cub. ft.), representing a total expenditure for fuel of 17,600 Swiss francs. To this must be added the wages of the fireman, the total cost amounting to a sum of 23,100 Swiss francs per year. This is only for fuel for the purpose of producing steam for a single process. A further example is furnished by a cotton-spinning mill of medium size, which consumes for the same process about 5,000 kilos. (11,000 lb.) of steam per day. The boilers are fired with pieces of beechwood and some other waste wood, and the yearly consumption is 1,090 cub. m. (38,000 cub. ft.), which means a yearly expenditure for fuel at the rate of 41 francs per cub. m. equal to $1{,}090 \times 41 = 44{,}700$ Swiss francs, plus 6,500 francs for fireman's wages, in all, therefore, 51,200 Swiss francs for working expenses only for steam used for this particular process.

An example of a coal-burning installation is furnished by a worsted yarn-spinning mill which requires for the purpose of washing the wool, &c., 12,000 kg. (26,000 lb.) of steam daily. The existing boiler plant is operated with American and Belgian coal, French "tout venant," Dutch turf (peat) and fir-wood chips (waste). Some 2·2 tons daily, or 660 tons of coal yearly are consumed, amounting to an expenditure of $660 \times 280 = 185{,}000$ Swiss francs. Add to this 8,400 francs for wages for the fireman, and a total expenditure of 193,400 Swiss francs results, and this only for fuel and operation of the boilers for this particular branch of industry. A chemical works requires for one of its branches 48,000 kg. (105,000 lb.) of steam per 24 hours' working, day and night shifts. The daily consumption of coal is 7·4 tons, equivalent to about 2,000 tons yearly. At the rate of 280 francs per ton, the yearly costs for the fuel works out to 560,000 Swiss francs plus 8,200 francs for firemen's wages, thus making a total per year of 568,200 francs for steam production only for one particular branch of manufacture.

The above few examples will sufficiently illustrate the present greatly increased working costs for steam users in Switzerland. These costs may be compared with the costs for producing electrical energy, the price of which, however, differs within a wide range. In the case of the various Swiss works which possess their own hydro-electric power plants, superfluous power is frequently available during the summer and likewise during the night, which might be used for steam raising electrically, while many buyers of electrical energy are often in a position by the introduction of electrical heating, to reduce their working expenses in a considerable measure. It is a well known feature of the Swiss Electrical industry, that in general there is a surplus of electrical energy during the summer months and at night time.

The problem of converting electrical energy into heat for steam raising does not involve practical difficulties, and electrical steam generators of the "Revel" type have proved very successful. They are of very compact construction, and the losses of heat due to radiation are slight. A "Revel" generator is shown in Fig. 1 on page 564. It has an overall diameter of 620 mm. (24 in.), and a total height of 2·5 m. (8 ft.). This boiler produces 550 kg. (1,200 lb.) of steam per hour at a gauge pressure of 15 atmospheres when the supply current is at 500 volts. The same boiler produces 250 kg. to 300 kg. of steam per hour with a voltage of 200 volts to 250 volts.

In January last the Swiss Association of Boiler Proprietors conducted some experiments on a "Revel" boiler, and in their report they make the following remarks:—

"The efficiency corresponds to an evaporation of 1·3 kg. (2·8 lb.) of so-called standard steam per kilowatt-hour. The quality of the steam produced is free of any objection, as it has a content of water of only about 3 per cent., compared with 5 per cent. to 10 per cent. humidity of steam produced by ordinary fixed boilers. The evaporation and heating of steam in the 'Revel' generator is accomplished within the immediate vicinity of the water level."

Some test-figures are given in the following table:

*Main Results of an Evaporation Test.*

| | |
|---|---|
| Manufacturer's No. of boiler | 2278 |
| Mean electrical tension | 219 volts |
| Ammeter readings | 384 amps. |
| Mean electrical energy readings of the kilowatt meter | 367 kw. |
| Mean electrical energy per hour | 146·7 kw.-hr. |
| Mean gauge pressure | 6·42 atm. |
| Mean temperature of feed water | 10 deg. C. (50 deg. F.) |
| Mean temperature of the waste water before check valve | 14 deg. C. (57 deg. F.) |
| Steam produced per kw.-hour (gross) | 1·356 kg. (2,763 lb.) |
| Water of 10 deg. C. (50 deg. F.) inlet temperature converted into steam of 100 deg. C. (212 deg. F.) (normal steam) | 1·284 kg. (2,824 lb.) per kw.-hr. |
| Water contained in the steam | 5·03 per cent. |
| The total quantity of feed water fed into the boiler was | 771·5 kg. (1,697 lb.) |
| Whilst 310·5 kg. (6,834 lb. of waste water were flowing out through the check valve, it follows, therefore, that the difference, equal to 461 kg. of water were converted into steam, and 310·5 kg. of waste water were raised from their initial temperature of 10 deg. C. to 14 deg. C. | |
| The efficiency of evaporation is therefore:— | |
| Heat utilised for steam production $461 \times 652 \cdot 6$ | 300·848 cal. |
| Necessary heat for raising the temperature of the waste water, $3{,}105 \times 4 =$ | 1·243 cal. |
| Total electrically generated effective heat | 302·090 cal. |
| Efficiency of evaporation | 95·3 per cent. |
| Converted for the heating of the water | 0·4 per cent. |
| Total efficiency | 95·7 per cent. |

Commenting on these results the report goes on to state: "As it will be seen 1 kw.-hour has converted 1·284 kg. (28 lb.) of water from 0 deg. C. into steam of 100 deg. C. (normal steam), therefore the efficiency of evaporation amounts to 95·7 per cent. Besides this, it must be borne in mind that the electrical energy used was only 146·7 kw. per hour, whilst the boiler was designed for a capacity of 200 kw. It is very likely that the actual boiler efficiency for the full capacity would be slightly better. The variation in steam pressure was

trifling during the tests, and the extraction of steam remained practically constant. The quantity of water entrained during the evaporation was very small, viz., 2 per cent. to 3 per cent., it will increase somewhat with increased capacity and unequal load of boiler."

The main features of the "Revel" steam generator" are the stationary diving-electrodes which penetrate the cover of the apparatus through openings provided. These electrodes dip more or

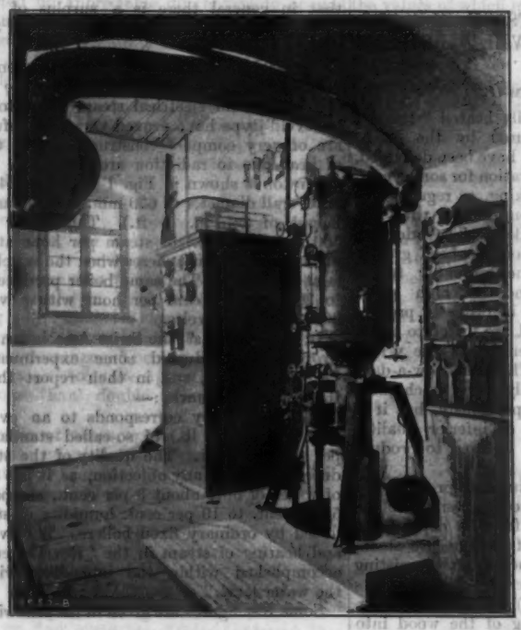


Fig. 1.

less into the water, according to the water level of the boiler. The intake of electrical current is regulated according to the quantity of steam required, and is easily arrived at by simply raising or lowering the water level. The steam production can easily be regulated within the limits of capacity of the boiler. After a lowering of the water level, the boiler will remain still under pressure, assuming that the steam stop valve has been closed. It then absorbs exactly the quantity of electrical energy corresponding to losses due by radiation and is always ready for further extraction of steam. Low water level in the boiler does not involve any danger, as in the case of ordinary boilers. The lowering of the water level, on the contrary, is one of the normal working operations.

The boiler has had many applications in Switzerland for factories requiring steam, or hot water, for process work, and as an actual example we may refer to a battery of three "Revel" generators situated in a chemical factory, having a total consumption of electrical energy of 2,100 kw. at 3,300 volts. This installation is working with a steam pressure of 8 atmospheres, and replaces a battery of Cornish boilers. In the case of another installation in a cotton-spinning mill, the current is available from the company's own hydro-electric power plant, and the steam demands do not synchronise with the power demands. It was, therefore, necessary to attach a sort of heat accumulator to the "Revel" boiler. This accumulator remains always partly filled with water, and on its lower end there is a steam mixing nozzle device. The steam produced by the "Revel" boiler is introduced directly into the water in the accumulator. As the temperature rises in the accumulator, the steam pressure increases until it reaches its normal working limit. After this state has been arrived at, the further steam supply from the "Revel" generator is stopped, and then the low-pressure steam to be used in the factory is extracted from the loaded accumulator according to the requirements of the factory, by a pressure-reducing valve, and the process is thus repeated over and over again.

A further installation, working with current available only at night-time, is illustrated in Fig. 2 subjoined. Steam storage boilers are installed, and the installation has a storage capacity of about 4,000,000 heat units. The plant is situated in a

Fig. 2.

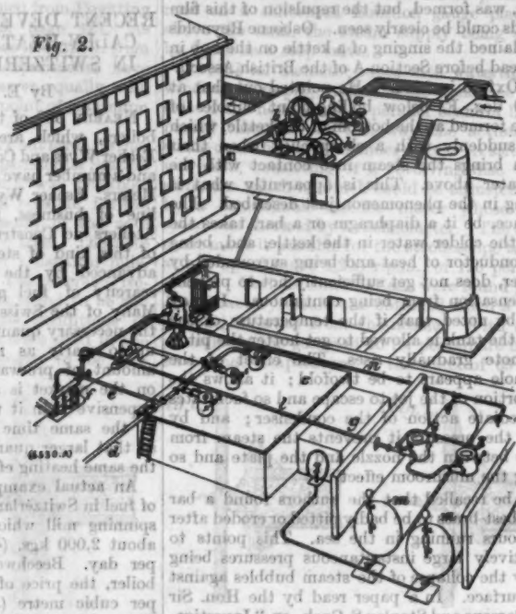


Fig. 3.

cotton-spinning and weaving mill. The power machinery which was in place prior to the installation of the "Revel" boiler consisted of a 500 h.p. Escher Wyss water turbine indicated at *a* in Fig. 2. A clutch shown at *b*, is fitted by means of which the water turbine may be kept working whilst the main shaft is at a standstill. A battery of boilers, shown at *c*, was in use, and from the main steam range two branches, *d* and *e*, were taken. The branch *d* led to a steam engine which acted as a stand-by when water power was not available. The steam branch *e* led to the steam distributor, *f*, from which branches were led for process work, heating, cooking, &c., to different departments of the factory. An economiser, shown at *g*, was also in use in connection with the original installation.

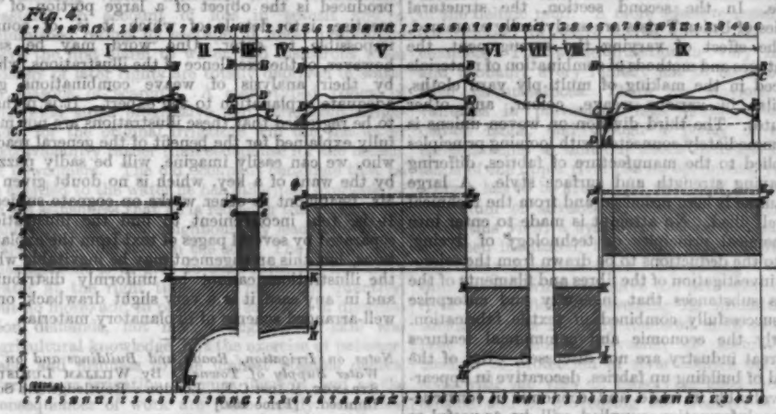
The main shaft of the installation was driven in summer time by the water turbine. During the winter, or when water was scarce, as also during cleaning operations of the canal, the supplementary steam engine had to drive the main shaft, for which purpose the whole battery of boilers had to be fired up. During the whole year one boiler had to be fired to produce the steam for the process work and for the heating system. This necessity was not of great importance before the war, but with the present price of fuel and level of wages, it became a serious item, and accordingly arrangements have been made, by installing a "Revel" steam generator, so that the ordinary boiler plant may be shut down entirely. The "Revel" boiler works in conjunction with a hydro-electrical plant driven by the water turbine at night.

In the water turbine house there is now installed an "Oerlikon" 3-phase generator, shown at *h*,

* Earlier articles dealing with the "Revel" boiler will be found in ENGINEERING, Vol. civ, page 468, and Vol. six, page 120.

of 350 kw., 500 volts, 50 cycles. This is connected by an underground cable to an Escher Wyss "Revel" boiler, 500 volts 15 atmospheres installed in the stokehold, and shown at *i*. The feed pump of the "Revel" boiler, driven by an electrical motor, is marked *k*. This pump delivers normal river water without any purification into the electric steam producer. As shown, a steam main connects the "Revel" boiler with the distributor, and a branch, *l*, is carried to two Escher Wyss steam storage boilers which have been installed, and are indicated at *m m*. Fig. 3 on page 564, shows one of these storage boilers on its way to the site. The storage boilers are built for 12 atmospheres working pressure, and 18 atmospheres test pressure. The internal diameter of each is 2 m. (6 ft. 6½ in.), the length overall being 10½ m. (34·4 ft.). They are constructed of Siemen's

*Fig. 4.*




I, III, V and IX.—Storage Boilers Charging. II, IV, VI and VIII.—Storage Boilers Discharging. VII.—Installation Shut Down.

A – A. Electric energy absorbed by the Revel boilers, 1 division 100 kw.
B – B. Steam pressure in the Revel boiler, 1 division 2 atmos.
C – C. Steam pressure in the storage boilers, 1 division 2 atmos.
D – D. Steam production of the Revel boiler, 1 division 100 kg. per hour.
E – E. Total absorption of energy of the Revel boiler in calories, 1 division 50,000 cals. per hour.
F – F. Useful calories produced by the Revel boiler, 1 division 50,000 cals. per hour.
G – G. Calories stored in the storage boilers, 1 division 50,000 cals. per hour.
H – H. Total calories drawn from the storage boilers, 1 division 50,000 cals. per hour.
J – J. Useful calories drawn from the storage boilers, 1 division 50,000 cals. per hour.
K – K. Calories remaining stored in the storage boilers, 1 division 50,000 cals. per hour.

Martin mild steel. The shell of each boiler consists of only three shell sections, each of 3·4 m. (11 ft.) length and 18 mm. (¾ in.) thick. The circumferential seams are lapped with two rows of rivets, while the longitudinal seams are of butt type, with double riveting. The ends are curved and support a total end pressure of 377 tons, under 12 atmospheres, or 565 tons under 18 atmospheres, without any reinforcing by flues or supporting tie rods. Each boiler is provided with a steam dome and the usual fittings, as well as with a simple device for noiseless entry and complete condensation of steam produced by the "Revel" boiler. Externally the storage boilers are covered with a double layer of insulated brick. A feed pipe, shown at *n*, is carried to the two boilers, and by means of it the boilers are filled with water, so that the water is just visible in the glass before the admission of the steam.

The installation works as follows: In the evening, when the water turbine is free to drive the electrical generator, the current produced is fed to the "Revel" boiler. The steam generated by the latter is then admitted to the storage boilers through main *l*. The steam is condensed by the water in the boilers, which it, of course, heats up. This operation is continued all night, so that the temperature of the steam storage boilers continually rises, as does also their steam pressure, and the level of the water. The "Revel" boiler is kept under a constant working pressure of about 13 atmospheres, by means of a simple automatic device. In the morning the storage boilers are filled up and are, under high pressure, ready to give steam. The "Revel" boiler is then put out of action, and the water turbine is freed to drive the main transmission shaft of the plant. The steam consumption required by the plant is covered during the whole day by the steam taken from the storage boilers. The pressure of the steam is reduced for distribution to about 2 atmospheres to 3 atmospheres, and the steam is directed to the various departments already mentioned. At noon, there is sometimes a short re-charging, and the discharge is continued in the afternoon. In the evening the nightly re-charge is started up again.

The diagram given in Fig. 4 shows the results of tests continued for two days and three nights, without interruption. The test results are chronologically plotted from left to right. The first period shows a charging at night, then follows a discharge during twelve hours, then again a charge at noon for one and a half hours, and again a discharge, and so on. Curve A-A shows the consumption of energy by the "Revel" boiler during the tests. Curve B-B shows the steam pressure in the "Revel" boiler. Curve C-C shows the steam pressure in the storage boilers. Curve D-D shows the steam output of the "Revel" boiler. This quantity is measured by the quantity of feed-water evaporated, and by the raising of the water level in the storage boilers. Curve E-E is the energy absorbed by the "Revel" boiler given in thermal units. Curve F-F shows that part of the heat losses of the installation due to the "Revel" boilers. This curve is characteristic for the "Revel" boiler. Curve G-G refers to heat losses of the storage boilers and the steam pipes. The space between the horizontal axis and the curve G-G is a measure for the net heat accumulated in the plant during the charge. Curve H-H shows the total gross heat taken from the two storage boilers, together. Curve J-J shows the heat losses of the latter. Curve K-K shows the heat remaining in the storage boilers. The difference between the curves G-G and the curves K-K is in direct connection with the increase of the water level in the storage boilers. This water quantity is once per day, in the evening, delivered into the economiser, and is thence taken for further utilisation. The amount of heat stored on the first test day was about 3·3 million heat units. The second test is 3,000,000 of heat units, whilst the pressure in the storage boilers varied between 3, 8·7 and 3·5 atmospheres. The second day about 3·6 million heat units were stored, the pressure in the storage boilers being between 3·5, 10·6 and 4·5 atmospheres. The thermal efficiency of a 24 hours' working period, including the "Revel" boiler and the steam distributor, is over 83 per cent., which is an excellent result. When more steam is required from the plant, the full pressure from 12 to 2·5 atmospheres will be utilised, with a daily accumulation of about 4,000,000 thermal units. The installation described is the largest hydro-electrical steam storage installation in Central Europe.

Swedish Locomotives for Russia.—According to *Swedish Report*, a contract has been concluded by Professor Lomonosoff on behalf of the Soviet Government and Messrs. Nydquist and Holm, in Trollhättan, for the delivery of 1,000 locomotives to Russia.

## THE INSTITUTION OF MECHANICAL ENGINEERS.

The first ordinary general meeting of the present session of the Institution of Mechanical Engineers was held on Friday, the 22nd inst., at Storey's Gate, Westminster, the president, Captain H. Riall Sankey, C.B., C.B.E., R.E. (retired), in the chair. The minutes of the summer meeting at Lincoln having been read in abstract, the President formally announced the retirement of Mr. E. Worthington from the position of secretary. After paying a tribute to the services rendered by Mr. Worthington to the Institution during the twenty-three years he had occupied the position, the President recommended for the approval of members the appointment to this position of Brigadier-General Magnus Mowatt, C.B.E. Mr. Pitt having seconded this, the election was approved by the members present. After General Mowat had expressed his thanks, the President stated that Mr. H. T. Chapman had been appointed assistant secretary for general business, and Mr. J. Montgomery assistant secretary for technical matters. Mr. G. Hughes, C.B.E., having retired from the council that body had co-opted Colonel A. Davidson, D.S.O., R.E., to fill the vacancy. It was then announced that 108 new members and associate members had been enrolled, and 13 transferences made by the council.

### Presidential Address.

The President then read his address. This we reproduce in abstract on page 583 of this issue. At its close Sir John Dewrance proposed a vote of thanks, and this was seconded by Mr. I. A. Legros, and passed with enthusiasm.

It was then announced that the Thomas Hawksley lecture would be delivered on November 5 by Sir R. Glazebrook, K.C.B., D.Sc., F.R.S., on "Limit Gauging." At the next ordinary meeting, November 19, a paper on "The Sterilisation of Water by Chlorine Gas" would be read by Captain J. S. Arthur, O.B.E.

### Alteration of Bye-Laws.

The meeting was then formed into an extraordinary one called to consider alterations in the bye-laws. The proposals which had been circulated to members were concerned with the institution of a grade of past vice-presidents, and the constitution of the council, on which it was proposed that not more than three past vice-presidents should sit, while chairmen of local branches might be co-opted while holding office. The proposals were seconded by Mr. Berry and Mr. Monkhouse. The first proposal was to constitute a grade of past vice-presidents, which was carried without discussion. On the second a discussion arose having for its object the election of representative associate members to the council of the Institution. Mr. G. H. Ayres moved a series of amendments to the council's proposal to affect this end. In view of subsequent events it is unnecessary for us to give a detailed report of these, or the arguments Mr. Ayres advanced in support of them. The amendments were seconded by Mr. C. A. Woodfield. A further amendment was also proposed by Mr. W. F. Cully, seconded by Mr. J. K. Aykroyd, with the idea of simplifying Mr. Ayres' proposals. During the discussion which ensued Messrs. G. W. Thompson and F. R. Wade spoke in favour of the amendments. Sir John Dewrance said that he thought the changes proposed by Mr. Ayres and Mr. Cully were not in the interests of the Institution. Dr. Hele-Shaw and Mr. E. R. Dolby also joined in the discussion, which was finally brought to a close by Mr. Richard Allen appealing to the proposers to withdraw their amendments and allow the council's proposals to pass, on the understanding that the subject of opening the way for the election of associate members to the council should be again reviewed and reported upon by the council, at an early date. This proposal being supported by the President, Mr. Ayres and Mr. Cully withdrew the amendments they had proposed, and the alterations to the bye-laws as defined in the forms circulated were then carried.

A special meeting to confirm these resolutions will be held on Friday, November 19, at 5.30 p.m., at the Institution.

# LITERATURE.

*Union Textile Fabrication.* By Roberts Beaumont M.Sc., M.I.Inst.E., late Professor of Textile Industries, Leeds University. London: Sir Isaac Pitman and Sons, Limited. [Price 21s. net.]

The newspapers, which have been discussing the possibility of a decline of prices in textile goods, have lately been lecturing the public on the relative merits of "Botany" serge, the demerits of "cross-breeds" or the virtues of some other fabrics with uncouth designations. A perplexed and disgruntled public have had various alternatives submitted to their judgment, but their advisers in their most expansive moments have hardly counselled the adoption of union fabrics as a means for exerting a serious pressure on those who have battened on public necessities. But this is the precise moment Mr. Beaumont chooses to explain some of the mysteries and advantages connected with union fabrication. He can tell those who look for relief from the present severe conditions, how a low-class yarn industry has been made a practical reality to the benefit of trade and the advantage of the community. The British manufacturer has led the way in economic yarn production by the utilisation of trade waste, and by his ingenuity and experiments has achieved a great success in cloth construction. He has attained a proficiency in the making of cloths from wool substitutes and "recovered" varieties of fibre, interwoven with cotton, that are satisfactory in firmness, durability and wearing properties. The greater carding efficiency acquired, the improved manipulation of the milling machines, together with the progress made in finishing methods, have supplied a material of quite superior handle and quality of piece. To speak ill of these products, indiscriminately, is to display both ignorance and injustice. Patient experiment, informed by technical knowledge, has produced a valuable branch of textile fabrics, which closely resemble makes of texture composed of pure wool, imitating colour style, and finish. Unfortunately, the public has seized upon this quality of imitation and condemned the result, as unworthy from an artistic point of view, and an insolent attempt to foist an adulterated article upon a deceived public. This attitude, which entirely overlooks the economic value of the material, has no doubt been encouraged by interested tradesmen, who have not scrupled to avail themselves of every method to disparage an article, that might tend to lower prices. In the early days of manufacture, it must be admitted that disparagement was easy, for defects were easily noticeable in the finished material, arising mainly from the want of exact and scientific procedure in dyeing. Even to-day, union cloths are advisedly restricted to heavily milled structures, firm and thick in build, and with a limited range of colours. But improved technique in dyeing and manufacture has brought on the market, with most satisfactory results, a large class of goods in which a cotton warp is combined with woollen weft. Such textural results in volume of manufactured products rival those of the Cheviot and Saxony yarns, and in some of its modern phases they overlap the Crossbreed and Botany worsted industries.

Though the manufacture of these substitutes is one of the subjects that the author discusses it must not be supposed that he is recommending or favouring any particular kind of manufacture. This would be utterly to misconceive the purpose of the book, in which is exhibited in an illuminating manner the accomplishments of the past whilst indicating the directions in which the most modern methods are moving. It is, however, useless to shut our eyes to the fact that throughout, the processes described are more or less connected with imitation, and are viewed with very considerable prejudice and mistrust by the public as shown by the frequent, but often erroneous, use of the offensive word "shoddy." If any discredit attaches to the production it is traceable to the deceit which is sometimes practised in misdescribing union fabrics as "all-wool." The manufacture is perfectly legitimate, and a full explanation of the methods employed is to be courted. Viewed in this light, the treatise is a welcome addition to the literature of the subject and though addressed mainly to technical students, yet the author has given his work such a character that many unconnected with the industry will be intelligently interested in learning by what means the decorative features that lend attractiveness to the products of the loom are created, and in gaining a precise knowledge of the improvements that it is possible to introduce into this class of fabric.

The treatise conveniently divides itself into three parts. In the first is considered the subject of bi-fibred manufacture, the possible combination of materials differing in physical structure, in chemical qualities and composition, that provide the ingredients for the fabric product. The treatment, blending and arrangement of these materials determine the colour tone, the pattern characteristics and the strength and durability of the finished texture. In the second section, the structural varieties of Union Twists are analytically examined, and the effect of varying the arrangement, the percentages and methods of combination of materials is traced in the making of multi-ply yarn cloths, dissimilar in various weave, colour, and other attributes. The third division on woven unions is more immediately connected with looming principles as applied to the manufacture of fabrics, differing in weaving strength and surface style. A large programme is here promised and from the technical side well filled. No attempt is made to enter into the chemical principles or technology of dyeing, nor into the deductions to be drawn from the microscopic investigation of the fibres and filaments of the various substances that ingenuity and enterprise have successfully combined in textile fabrication. Similarly the economic and commercial features of a great industry are not discussed. But of the method of building up fabrics, decorative in appearance, valuable in trade and economic in construction the information supplied will be as useful as it is accurate. The technical student should imbibe sound principles of weaving in the fabrication of bi-fibred yarns, and the designer will learn the opportunities for creating distinctive pattern features in the finished goods and the limitations imposed by mechanical processes.

The materials used in union fabrication may be, and are, combined in various ways, each requiring peculiar technical treatment. The union may be effected by combing two or more distinct classes of fibre in thread preparation; two or more classes of fibres may be twisted into one yarn unit, and in the so-called union yarn fabrics, yarn structures differing in filament composition may be woven together into the fabric. Under these last conditions, the cotton and wool ingredients, for example, remain separate units, being simply interlaced in the operation of weaving. The object of such combination of animal and vegetable fibres is to form a texture having the surface features and the salient characteristics of a cloth made of yarn of animal origin. A convenient practice in union fabric-weaving is to use one description of yarn for warp, and a distinct variety for weft. It is obvious that where each thread has a special function in the weaving process, the face, centre and back of the fabric can be formed of dissimilar kinds of yarn, effecting a very considerable economy.

Variations on the general plan are numerous. Two or more sorts of yarn may be used in the warp crossed by different sorts of weft yarn, or yarns of distinct fibrous composition may be used in sectional parts of the warp or weft giving rise to striped or checked patterns with the ground portions of the fabric woven in yarns of another quality. An elaboration of this last process permits the introduction of yarns of special counts and varieties of fibre, producing spotted, figured, and design details. Ample scope, therefore, is given to the artist and the manufacturer for the production of every variety of fabric, but the processes have been reduced to method and adapted to mechanical operation only by the exercise of much skill and ingenuity. In the book under notice the author demonstrates the several processes fully and clearly.

The capacity for variety of production is still further emphasised when colour schemes are combined with the general weaving operations, for then the physical structure and chemical composition of the separate fibres as well as the make of the fabric and the practice of finishing, determine, or at least modify, the tone and quality of the product. Each and all of these technicalities are factors to be turned to account in the dyeing scheme. Usually the fabric is woven in the uncoloured state and the coloured effects are developed by process dyeing in the piece, advantage being taken of the varying resistance that the different materials offer to the action of dyes. In bi-fibred yarns, design and style are in a large measure due to the arrangement and grouping of yarns of different filament consistency in the warp and weft. Colour as a distinctive pattern characteristic is latent in the material as is a picture in an exposed photographic film. The dyeing reveals the pattern, as the developing action discloses the photographed picture, and to explain how the varied effects are produced is the object of a large portion of the treatise, into details of which it is, of course, impossible to enter. One word may be said, however, of the excellence of the illustrations, which by their analysis of weave combinations give adequate explanation to the expert. It is perhaps to be regretted that these illustrations are not more fully explained for the benefit of the general reader, who, we can easily imagine, will be sadly puzzled by the want of a key, which is no doubt given by Mr. Beaumont in other works on cognate subjects. It is, too, inconvenient to find the illustrations separated by several pages of text from the explanations, but this arrangement may be inevitable when the illustrations cannot be uniformly distributed and in any case it is a very slight drawback on a well-arranged scheme of explanatory material.

*Notes on Irrigation, Roads and Buildings and on the Water Supply of Towns.* By William Lumisden Strange, M.Inst.C.E. London: Routledge and Sons, Limited. [Price 45s.]

The title of this book suggests a very comprehensive work, and the contents range over a large variety of subjects. It will be observed that the author describes these as "Notes," and such a term does not imply either complete development or consecutiveness. His object, or at least one of them, is to preserve the practical knowledge gained by a long experience and to make that information available to those who have to tread the same path that the author has pursued, but without similar guidance. Mr. Strange has served under various Indian and Colonial Governments, and having been attached to that branch of the Indian Public Works Department known as the "Irrigation, Roads and Buildings," the combination does not seem to him either unusual or inconvenient; moreover, as he explains, in the East the engineer plays many parts and occasionally all at the same time. These "Notes" refer generally to the smaller class of works, as these are more frequently undertaken by the younger professionals to whom the book is addressed. In the case of large schemes, the designers have their own experience and the plans adopted in similar undertakings on which to rely.

Irrigation occupies the largest space in the volume, and this might be expected if we consider the importance of the works and their effect on the community. A roadway may be a convenience to promote intercourse and to facilitate transport, but an irrigation canal may be a necessity on which life and existence depend. Its functions may be to preserve waste waters and to prevent destructive floods, but it effects far more than these obvious purposes. It converts valueless land into productive farms and enables many families to settle upon small tracts sufficient for their support. It provides opportunities for those who have skill, energy and resource, to lay the foundations of continued prosperity, so that an increasing number of families can maintain themselves upon the subdivision of the original farms. Mr. Strange contends that irrigation is a factor in civilisation, and he is right, for the greater prosperity and success of the agricultural inhabitants reacts on the advancement of the whole population. Certainly in India, where well irrigation has long been practised and partial systems under native control are being continually linked up with Government schemes, the problems arising do not concern engineers alone, they enter into many social and economic questions, which complicate the course of Indian government. In

some countries, as in the Western States of America, settlement has been rendered possible only by irrigation schemes, and the supply of water and the growth of population have progressed simultaneously, but in India the old settled population and original irrigators have shown strong opposition to any curtailment of what they consider their rights, and have resented the intrusion of new comers who might interfere with their claims. In times of scarcity, friction is likely to arise when limitations are imposed by the enforcement of a rotational supply. Those in possession of ancient rights demand the maintenance of the principle of priority, which entitles irrigators to their supply in the order in which they originally claimed their rights to it. Although this principle may be defended in law, as securing vested interests, it is economically wasteful on account of loss in transit and a diminished return by seepage, if lower proprietors have the first claim to water, and disastrous when holders of later rights are totally deprived of water in seasons of scarcity. A stereotyped policy of this kind stops progressive and permanent irrigation, for the original irrigators will use the water extravagantly rather than economise for the benefit of newcomers. The old occupant considers that he is entitled to the water he has inherited, overlooking in his selfishness that he is reducing the value of his land and that of his neighbours by leaching out the valuable soluble salts in the soil. The aim of good management is to give to each farm the necessary water at the right time, and in proper quantity, but no more, and to plan out a schedule of distribution demands, not merely engineering skill and agricultural knowledge, but the exercise of patience, tact, and firmness to the highest possible degree. Perhaps as irrigation schemes develop, and as the consequences of work are more clearly recognised and the efforts to secure the common good are better appreciated, economic practice will crystallise into custom, and custom into established laws and regulations, making the control of water easier and more certain, but to judge from the author's remarks on "Law, Finance and Administration," these halcyon days are afar off, and the function of the engineers who operate, it may be, hundreds of miles of ditches, delivering water to hundreds of farms, is no sinecure.

These questions of distribution and utilisation of water debated at the beginning and the end of the treatise are of great importance to the student of sociology, but may be regarded by the engineer only as an ornamental fringe to the main purposes of the book, which discusses the principles that decide the arrangements and guide the construction of the mechanism, indispensable to the proper working of an irrigation system. Starting from the collection and preparation of the data for determining the volume of water that may reasonably be expected from a catchment area, the necessities, difficulties and losses from storage are considered. Storage requires the erection of dams, the construction of reservoirs, and the provision of weirs and escapes. These are the spectacular parts of the scheme that arrest attention, but the canals and distributaries that lead the water from the main sources of supply to feed the minor lines and by gradually narrowing ways convey the water to the fields, demand equal care in the planning and call for continual watchfulness and attention, if the working of the scheme is to be a success. In alluvial lands, such as many of the streams of India traverse, the maintenance of these works is a matter of anxiety on account of the uncertainty of the extent of high floods. Abnormal floods may rise proportionately higher than in non-alluvial country with steeper slopes, or may have greater scouring action on the beds of channels. Since in an Indian alluvial river the channel is usually insufficient to contain these floods, a knowledge of the behaviour and of the physics of these rivers is eagerly sought. The author examines several theories, particularly those due to Molloy and to Oldham, and is inclined to look more favourably on the views of the first named authority, as more consistent with observation, though no decided conclusion is drawn. The one fact that stands out very prominently is the instability of the regime of an alluvial river, and how greatly that instability depends upon the great variation of the discharge during the high flood and the low water season. The fertility of the soil is increased by the periodic floods, and therefore it is in these flooded areas that there is the strongest temptation to cultivate the soil, but the constant change in the course of the channels and the liability to submergence bring acute disappointment to the agriculturist, and consequently some alleviation of such adverse conditions is naturally sought. The regulation of the discharges is the object to be gained, so that the channels may preserve their courses unaltered, neither increased by scouring and overflows nor lessened by silting. The prevention of frequent meandering can sometimes be effected by spurs projecting into the current, so as to deflect it from places threatened by its attack, but the method often fails on account of the erodability of the deltaic mud. A more effective means is the construction of weirs across the heads of the channels. The whole question is very involved and probably every remedy has to be decided by local circumstances. There are obvious disadvantages in preventing high floods submerging deltaic lands, and though a policy of erecting embankments to shut out floods from the riparian lands of the upper river has its opponents, yet some scheme has to be attempted that shall continue the maximum of advantage with the minimum loss. With this view, a system of retired embankments has been instituted, that is by raised banks built well away from the river. By adding "reclamation bunds," which preserve the permanence of the river by artificially increasing its sinuosities, the construction is not only rendered more secure but post inundation cultivation is secured. This method of protection of river courses on alluvial soils with the view of preserving good land from erosion and of preventing the creation of sterile sand banks seems to be effective and to be frequently employed. The arguments for and against the practice are fully set out, but the necessity of obtaining that sense of security which is essential to progress turns the scale in favour of adoption.

The protection of irrigated lands from seepage and waterlogging is as important as the increase of productivity, but we must be content with saying that irrigation projects in their entirety have been a success, that the money spent in their construction and preservation has been well invested, but apart from all financial considerations, a scheme that adds to the welfare of the native population and gives enlarged opportunities for production is deserving of close study and attention by others than those actually engaged in widening its extent and increasing its capacity.

The addition of a section on the water supply of towns has something of the appearance of an excrescence or anticlimax, but the reason for its inclusion has already been given. The conditions that obtain in India are not greatly different from those found elsewhere, but the periods of drought may be longer, the amount of evaporation greater, the seasonal variations more marked, and therefore the need for ample supply more pressing. The prevalence of waterborne diseases as typhoid, cholera, dysentry, &c., requires the exercise of greater care in the chemical and bacterial examination of potable water, while the very general use of wells increases the possible sources of impurities and makes the elimination of pathogenic germs more difficult. The methods of purification and filtration are described, but there is no general variation from those generally employed. The author is aware of the need of enforcing stringent precautions for securing freedom from pollution of the water supply on gathering grounds, but the country generally does not seem alive to the importance of maintaining the standard of purity of the water at the levels demanded by modern hygiene. Apparently, no attention is given to protection from fire, at least outside the largest towns. The description of conveyance of water by aqueducts, conduits, and mains, &c., follows the usual lines, and one reads with satisfaction that the tropical climate of India has little ill-effect on the life of pipes or on the extent of corrosion and of deposits. Wooden pipes buried in the ground have a long life, and though stave pipes have had but a short trial, they compare very favourably with thick steel pipes, though the steel bands round the stave pipes deteriorate rapidly and must be regarded as a weak point.

In the section devoted to road construction the remarks are generally limited to the making of district and rural roads, where only the water-bound forms are financially practicable and justifiable. The qualities insisted upon are naturally efficient drainage, the necessity for solid but elastic foundations, and the building up of a compact impervious and durable surface. Tar macadam and asphalt preparations are referred to as welcome additions in urban districts, but as too luxurious for general use. The description given of these latter is generally founded on English practice, as little experience has yet been acquired in the tropics.

The fourth part of this long book of 850 pages is devoted to district building projects, a species of work in which the engineer co-operates with the architect, and the former is advised to recognise his limitations in the matter of design. The class of buildings contemplated is limited to those intended for residents in tropical and subtropical areas engaged in Government service and Government buildings generally. The remarks and advice are as practical as they are minute, extending even to the ingredients of an approved furniture polish and its method of application.

---

*Technical Writing.* By T. A. Rickard, Editor of *The Mining and Scientific Press*, San Francisco. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 7s. 6d. net.]

It is curious and interesting to note the greater attention that is being paid to the maintenance of precision of statement and accuracy of expression in the preparation of scientific and technical works. This increased vigilance is deserving of encouragement, for the introduction of American and foreign words during the war, and the spread of certain popular forms of newspaper in which smartness and vulgarity are mistaken for wit, have tended to weaken some wholesome restraints that checked undue exuberance of language. Improvement and extension of the English we use are necessary, but it is equally desirable to prevent the incursion of vulgar and local phraseology, that cannot but have an evil influence. Science circulates freely throughout the world and the written English passes into all hands. To facilitate translation and to preserve accuracy, a uniform vocabulary and a recognised syntax are necessary, and it is our duty and our privilege to maintain these essentials in their purity and integrity. As the custodians of a valuable heritage, we are constrained to keep the language free from corruptions and uncouth additions, to develop it along lines that will maintain its character and to take such precautions, that those who come after us shall receive the great literature we have inherited as a living and intelligible vehicle of communication for the expression of the wide experience and sound knowledge that have been collected by many workers. For some time past, the opinion has been current that the interests of literature and science are at variance, and the supporters of a purely literary education have so far travestied the views of scientists, as to represent them as opposed to the acquisition of classical attainments. Even less vehement partisans are disposed to assume that a gulf is fixed between science and literature, or between information and entertainment, but such a view has neither warrant nor foundation. To make its truths readily acceptable, science cannot afford to neglect the assistance that good English and careful expression can supply.

The book now under notice, which has its origin in a series of lectures, delivered by the author to the engineering classes in the University of California, affords a proof of the importance that educational authorities attach to the use of accurate language, and the need of presenting facts in an agreeable and accurate manner. The Academical Senate perceived and regretted that while the student was constantly subjected by his environment to the unedifying influence of myriad examples of poor English, and that this evil was aggravated by a certain public prejudice against correctness of expression, little was being done to foster a taste for greater nicety of language or to create a public

# 40-B.H.P. MARINE TWO-CYCLE HOT-BULB OIL ENGINE.

**CONSTRUCTED BY MESSRS. NORRIS, HENTY, AND GARDNERS, LIMITED, ENGINEERS, LONDON.**

(*For Description, see opposite Page.*)

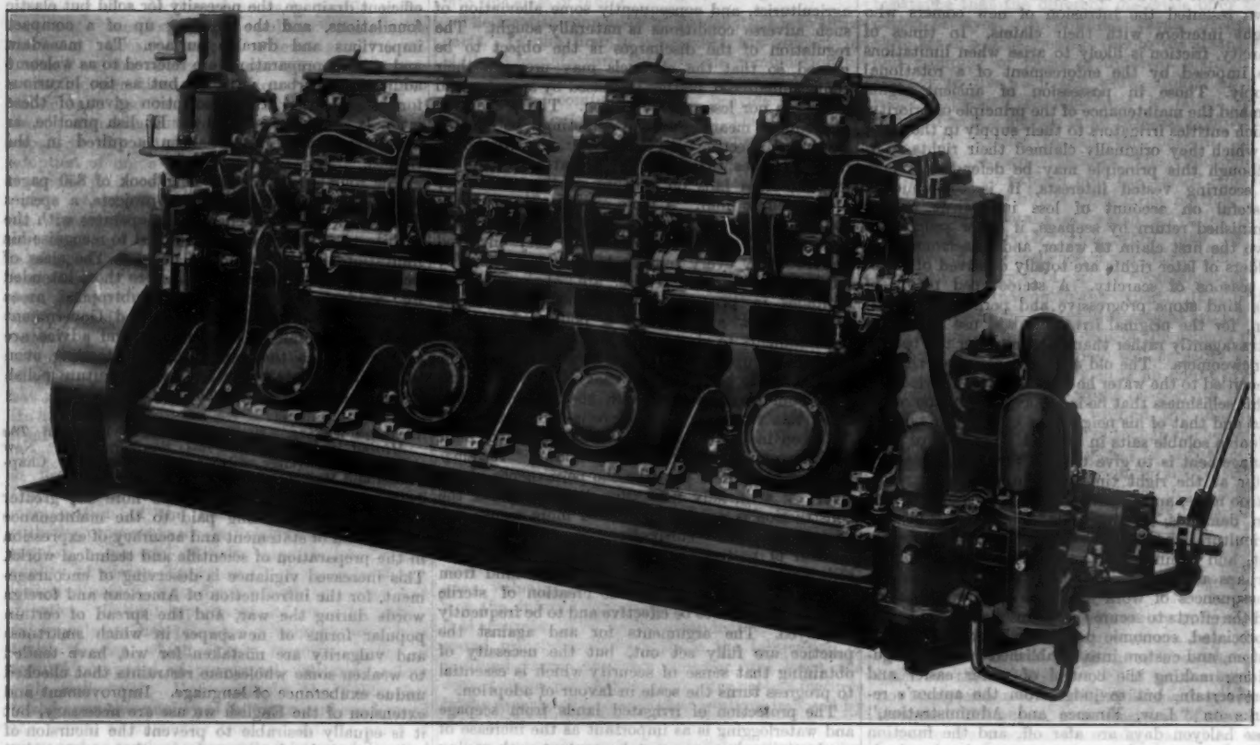


FIG. 1.

opinion that should prove an adequate corrective. To remedy these defects and to make the students appreciate the necessity of exercising care and system in the preparation of written papers, this course of lectures was inaugurated. The selection of the lecturer was happy. He possessed wide experience as an engineer, and knew the difficulties with which students had to contend. He had also filled the editor's chair of an important technical journal, and in that capacity had had ample opportunity of noting how frequently those, whose faculties had been trained in a special direction, failed, when engaged on the less familiar ground of recording their experience.

Such a lecturer was likely to prove both able and sympathetic. He would not expect that his precepts and recommendations, or, indeed, his criticisms of the work of others, should be accepted with the unquestioning reverence paid to authority. His object was to induce thoughtful discriminating study. Judging from the volume before us, he evidently considered that he would have succeeded in his object, if he made a careless writer careful, awakened an interest in the proper use of language, and made the importance of exactness in literary expression better appreciated.

To accomplish this purpose he gives much good advice in a palatable form, which it is to be hoped will not be passed by heedlessly. Among these precepts will be found one, frequently repeated, that is too often disregarded: "Remember the reader." That is an injunction or reminder to communicate facts and comments in language that can be readily apprehended. Fitness of diction consists in the choice of words that assist accurate expression, not in florid phraseology or rhetorical flourishes that signify little or nothing. "Put your self in the place of the reader," "remember it is he that has to be informed and instructed," is good general advice that is often overlooked. From these and other general maxims the author proceeds to the discussion of the particular faults that disfigure the work of writers, whether of mature experience or tyros in the art. The main principles of grammar and syntax are passed under review, the misuse or unfitness of certain words is demonstrated, the functions of relative pronouns and prepositions are discussed, the convenience resulting from the proper use of hyphens is pointed out and the lucidity that follows accurate punctuation duly emphasised. There may be little that is new or startling in the volume, but there is certainly much that is well worthy of consideration. The author admits that errors are often rather the consequences of thoughtlessness than of ignorance, and that inattention and carelessness bring about obscurity more frequently than does want of knowledge.

## BOOKS RECEIVED.

*The Chemical Analysis of Steel-Works' Materials.* By FRED. IBBOTSON, B.Sc., F.R.C.Sc.I., F.I.C. London: Longmans, Green and Co. [Price 21*s.* net.]

*The Fireman's Handbook and Guide to Fuel Economy. A Simple Manual for the use of Stokers, Furnacemen, Foremen and Operating and Controlling Boiler and Furnace Plant.* By CHAS. F. WADE, A.M.I.Mech.E., A.M.I.E.E. London: Longmans, Green and Co. [Price 2*s.* 6*d.* net.]

*Department of Scientific and Industrial Research. Fuel Research Board.* Special Report No. 2. *The Coal. Fyfe.* A research by MARGARET WHITE FISHENDEN, D.Sc., for the Manchester Corporation, Air Pollution Advisory Board. London: H.M. Stationery Office. [Price 4*s.* net.]

*The Electricity (Supply) Act, 1919, with Notes.* By W. S. KENNEDY, LL.B. London: *The Electrical Review*, Limited. [Price 3*s.* 6*d.* net.]

*Medical Research Council, Special Report Series, No. 52. The Science of Ventilation and Open Air Treatment.* Part II. By LEONARD HILL, M.B., F.R.S. London: His Majesty's Stationery Office.

*Debentures: The Purposes they Serve and how they are Issued.* By HERBERT W. JORDAN. Ninth edition. London: Jordan and Sons, Limited. [Price 1*s.* 6*d.* net.]

*The Motor Cyclists' A.B.C.* Edited by HORACE WYATT. London: George Newnes, Limited. [Price 2*s.* net.]

*Applied Naval Architecture.* By W. J. LOVETT, M.I.N.A. London: Longmans, Green and Co. [Price 36*s.* net.]

*United States Geological Survey.* II: 1. *Fuel Briquetting in 1916.* By C. E. LESHER. II: 2. *Sand-Lime Brick in 1916.* By JEFFERSON MIDDLETON. II: 3. *Phosphate Rock in 1917. With Notes on Phosphorus.* By RALPH W. STONE. II: 4. *Sulphur, Pyrites and Sulphuric Acid in 1917.* By PHILIP S. SMITH. II: 6. *Phosphate Rock in 1916.* By RALPH W. STONE. II: 8. *Slate in 1916.* By G. F. LOUGHLIN. II: 9. *Slate in 1917.* By G. F. LOUGHLIN. II: 10. *Feldspar in 1917.* By FRANK J. KATZ. II: 11. *Gems and Precious Stones in 1917.* By WALDEMAR T. SCHALLER. II: 12. *Salt, Bromine and Calcium Chloride in 1917.* By RALPH W. STONE. II: 13. *Salt Bromine and Calcium Chloride in 1916.* By RALPH W. STONE. II: 14. *Thorium Minerals in 1916.* By WALDEMAR T. SCHALLER. II: 15. *Sand-Lime Brick in 1917.* By JEFFERSON MIDDLETON. II: 16. *Silica in 1917.* By FRANK J. KATZ. II: 17. *Gypsum in 1916.* By RALPH W. STONE. II: 18. *Phosphate Rock in 1916.* By W. C. PHALEN. *With Simple Tests for Phosphate.* By W. B. HICKS. II: 19. *Fuller's Earth in 1917.* By JEFFERSON MIDDLETON. II: 20. *Peat in 1916.* By JAMES S. TURP. II: 21. *Mica in 1916.* By WALDEMAR T. SCHALLER. II: 22. *Fluorspar and Cryolite in 1917.* By ERNEST F. BURCHARD. II: 23. *Sand and Gravel in 1916.* By R. W. STONE. II: 26. *Coal in 1916.* Part B. *Distribution and Consumption.* By C. E. LESHER. II: 27. *Petroleum in 1916.* By JOHN D. NORTHROP. II: 28. *Stone in 1915.* By G. F. LOUGHLIN. II: 29. *Lime in 1916.* By G. F. LOUGHLIN. II: 30. *Clay-Working Industries and Building Operations in the Larger Cities in 1915.* By JEFFERSON MIDDLETON. II: 31. *Natural Gas in 1915.* By JOHN D. NORTHROP. II: 35. *Coal in 1916.* By C. E. LESHER. II: 36. *Stone in 1916.* By G. F. LOUGHLIN. Washington: Government Printing Office.

*The British Corporation for the Survey and Registry of Shipping. Rules for Classification and Construction.* Glasgow: Published by the Association.

*The British Corporation for the Survey and Registry of Shipping. Register of Vessels, 1890–1920.* Glasgow: Published by the Association.

*Handbook of Patent Law of all Countries.* By W. P. THOMPSON. Eighteenth edition, completely revised. London: Stevens and Sons, Limited. [Price 6*s.* net.]

*United States Bureau of Standards.* Circular No. 92. *Operation and Care of Vehicle-Type Batteries.* [Price 30 cents.] Scientific Papers, No. 381. *An Electron Tube Transmitter of Completely Modulated Waves.* By LEWIS M. HULL. [Price 5 cents.] Washington: Government Printing Office.

*Margarine.* By WILLIAM CLAYTON, M.Sc. London: Longmans, Green and Co. [Price 14*s.* net.]

# 40-B.H.P. MARINE TWO-CYCLE HOT-BULB OIL ENGINE.

CONSTRUCTED BY MESSRS. NORRIS, HENTY AND GARDNERS, LIMITED, ENGINEERS, LONDON.

Fig. 21. LUBRICATOR

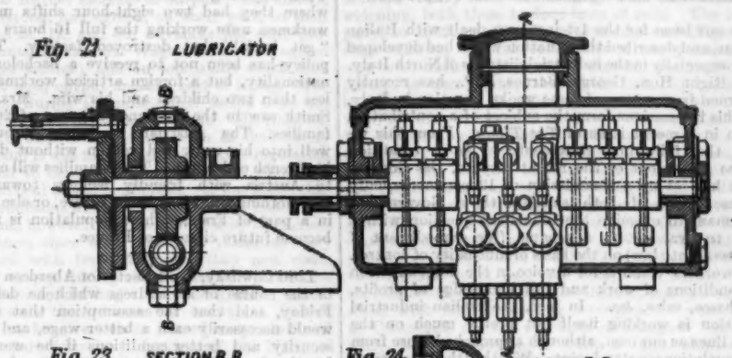


Fig. 22. SECTION A.A.

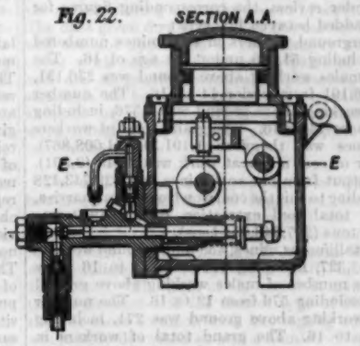



Fig. 23. SECTION B.B.

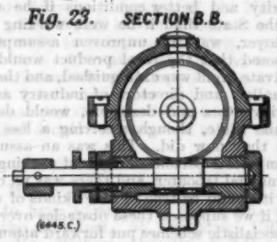



Fig. 24. SECTION E.E.

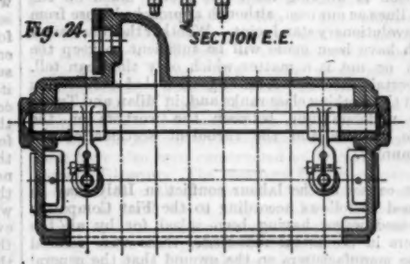
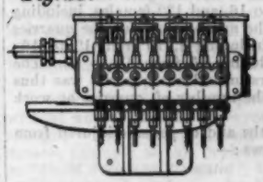


Fig. 25.



A two stroke four-cylinder oil engine by Messrs. Norris, Henty and Gardners, Limited, Gardner House, Queen Victoria-street, E.C.4, is illustrated in our two-page plate with this issue, and on the opposite and the present pages. This engine is of the marine type and is fitted with reversing gear and with bilge, circulating, air and lubricating pumps. It has 7 in. cylinders by 8 in. stroke, and runs at 400 r.p.m., developing 40 brake horse-power at that speed. A general view of the engine is given in Fig. 1, opposite, and elevations and sections in Figs. 2 and 3, on Plate LXV. The remaining illustrations are of details, to which we shall refer as we proceed with our description. The engine has trunk pistons. Each cylinder and jacket is one casting. The cylinder heads are separate jacketted castings. They carry the starting valves and fuel sprayer. The crank case is in two parts, the upper taking the cylinders and the lower the main bearings. The bearings of bronze are entirely isolated from the crank-case by means of air-tight metal floating rings. They are accessible while the engine is running without interfering with the crank-case compression. The pistons are of the plain trunk type with four rings, fitted with locating pins. The gudgeon pins are held in position by set screws. The connecting rods have big ends fitted with brasses lined with white metal, the little ends being fitted with a split phosphor bronze bush with set-screw adjustments. The crankshaft is furnished with balance weights secured by through bolts.

Each cylinder is fitted with the fuel injection pump shown in Fig. 5, the sprayer fitted to the cylinder heads being shown in Fig. 11. The fuel pumps are operated by a cam shaft driven by a vertical worm shaft shown at the left hand end of the engine in Figs. 1 and 2. These pumps are mounted on brackets which carry the cam shaft and rocking lever (Fig. 5). Underneath, this bracket has a lug which carries a separate shaft to which other cams are fitted. The pumps are put out of action for stopping and reversing by rotating this shaft by the lower lever shown in Fig. 18, so that the cams come in contact with the rocking levers, holding them clear of the pump cams. The fuel sprayer is arranged so that it can be rotated in the cylinder head; by this means the direction of the spray of fuel is altered. Normally, when under load the fuel is sprayed on to the finger of the hot bulb ring shown separately in Fig. 4. When running light the spray is directed up into the head. This helps to keep the engine running dead slow without extraneous heating being necessary. The governor is shown with the reversing gear in Figs. 12-14, the governing shaft to the fuel pump being shown in Fig. 5. The governor is of the centrifugal type, spring controlled, and by means of a shaft and levers raises or lowers wedges interposed between the striker of the rocking lever and the plunger of the fuel pump. The wedges are provided with flexible attachment to prevent straining by a governor control movement when any of the wedges are engaged. Speed variation is obtained by a handle at the head of the vertical shaft, by means of which the load on the governor springs can be varied by a worm gear.

Fig. 26. LAMP CYL.

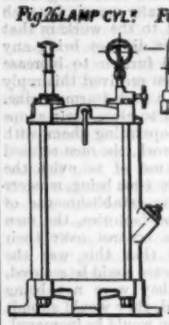


Fig. 27. BURNER FOR STARTING (MARINE TYPE)

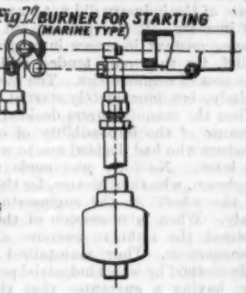
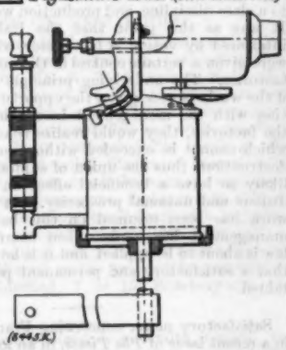


Fig. 28. HAND LAMP (STATIONARY TYPE)




Reversing is secured by moving the driving worm on this shaft relatively to the cam shaft worm wheel. This movement is secured with the handwheel and screw to the right of Fig. 12, the gear being also shown in the detail Fig. 14. The effect of this vertical movement of the worm is to rotate the cam shaft, thus altering the timing of the fuel injection, the adjustment being sufficient to cover the required range for running in both directions. The operations of reversing are as follows:—The fuel pumps are put out of action, as already explained, the timing cams are then corrected for the reverse, and the pumps engaged again, and the engine restarted on compressed air. The first action is brought about by moving the lower hand lever in Figs. 17 and 18, as already explained. The compressed air supply to the cylinders is controlled by rocking levers mounted on eccentric bushes on the upper shaft in Figs. 17 and 18 and cams on the main cam shaft, the air valves being shown in section in Fig. 3. At the same time as these levers are thrown into gear the main air valve is opened to the service pipe. Air at a pressure of 150–200 lb. per sq. in. is stored in a reservoir for starting purposes. This is supplied by a single stage water-cooled compressor shown in Figs. 6 and 8, driven off the crankshaft by eccentric. Water circulation is maintained by the circulating pump shown in Figs. 6 and 7, the valves of which are given in the detail Fig. 9.

The lubricating pump is shown to the left of Figs. 6 and 7, and its valves in Fig. 10. This supplies all the main bearings with oil through a main and branch pipes. A relief valve, Fig. 20, is fitted, allowing surplus oil to return to the sump. The cylinders, pistons and connecting rods are lubricated by means of a battery of small pumps driven by worm and shaft, one pump being furnished for each cylinder which is lubricated at two points, and one for each connecting rod. For the latter the oil is delivered into a centrifugal duct on the crank web. From this it passes through the crank pin to the big end. The connecting rod is drilled up the centre, thus allowing the oil to pass up to the little end and gudgeon pin. A hand-wheel, shown in Fig. 21, of the group of Figs. 21 to 25, on this page, which illustrate this system of mechanical lubrication, enables these pumps to be operated by hand for flushing or starting up. Each of the feeds is both sight feed and positive, as may be seen in Fig. 22.

The exhaust silencer, which is water-cooled, is shown in Figs. 15 and 16. The bilge pump is driven direct from the crankshaft, as shown in Figs. 7 and 19, and can be engaged by a small expanding clutch.

The hot bulb is a special feature of this engine. The unjacketted portion consists of two parts, a cap and a ring with radial gills, and an internal finger on to which the fuel is normally injected, as previously described. The hot bulb and ring are held in place by an external ring and clamping studs, this arrangement allowing freedom of contraction and expansion. For preliminary starting the lamp and cylinder (Figs. 28 and 26) used in the stationary engines are replaced in the marine engine by the burner shown in Fig. 27. These burners are of the oil spray type, taking their fuel from a gravity or pressure supply and served by air under pressure from the receiver. The engine will start up from cold in about four minutes.

The two-stroke engine offers many advantages for marine work owing to the ease of reversing and simplicity of running, and as worked out in this engine manœuvring and starting, are both simple and quick in action. The firm builds marine engines of this type up to 120 b.h.p., with four cylinders.

---

IMPORTS OF COAL TO SWEDEN.—We read in *Swedish Export* that the importation of coal to Sweden during the summer months has been comparatively large. The exports to Sweden of coal, coke and briquettes during July amounted to about 32,000 tons, and, as some cargoes of American coal have also arrived there this year, the situation may be looked upon as fairly satisfactory, although the outlook for the future on the fuel market is not particularly bright.

## INDUSTRIAL NOTES.

The Mines and Quarries General Report for 1919 has recently been issued by the Chief Inspector of Mines. From this we take the following figures for the year under review, the corresponding figures for 1918 being added between brackets :—

The underground workers in coal mines numbered 945,806, including 54,086 under the age of 16. The number of males working above ground was 236,131, including 26,191 from under 14 to 16. The number of females working above ground was 9,376, including 620 from under 14 to 16. The grand total of workers in coal mines was therefore 1,191,313 (1,008,867). The number of coal mines at work was 2,943 (2,801). The coal output from the coal mines was 229,743,128 tons, and adding to this the coal won from open quarries, 36,389, the total coal extraction during 1919 was 229,779,517 tons (227,748,654 tons).

In the metalliferous mines, the underground workers numbered 12,327, including 111 from 13 to 16 years of age. The number of males working above ground was 9,063, including 576 from 12 to 16. The number of females working above ground was 271, including 21 from 14 to 16. The grand total of workers in metalliferous mines was therefore 21,661 (20,821). The metalliferous mines at work numbered 495 (474).

In the quarries there worked 36,747 males, including 699 from 12 to 16, and 132 females, including six from 14 to 16. The numbers outside the quarries were, males 19,888, including 1,119 from 12 to 16; and females 309, including 15 from 14 to 16. The grand total of workers in and out quarries was thus 57,076 (43,215), and the number of quarries at work was 5,135 (4,362).

The number of deaths and of persons injured from accidents were as follows :—

| | Deaths. | Injured. |
|---|---|---|
| Coal mines— | | |
| Underground ... | 1,003 | 106,573 |
| On surface .... .... | 115 | 10,849 |
| Metalliferous mines— | | |
| Underground .... | 60 | 832 |
| On surface .... .... | 5 | 275 |
| Quarries— | | |
| Inside quarries .... | 34 | 1,984 |
| Outside quarries .... | 12 | 712 |

The death rate in coal mines from all accidents, under and above ground, per 1,000,000 tons of coal raised was 4·67 (5·86).

The death rate per 1,000 persons employed from all causes works out as follows :—

| | | |
|---|---|---|
| Coal mines— | | |
| Underground .... | 1·06 | (1·61) |
| Above ground .... | 0·47 | (0·58) |
| Under and above ground .... .... | 0·94 | (1·39) |
| Metalliferous mines— | | |
| Underground .... | 4·87 | (1·39) |
| Above ground .... | 0·54 | (0·23) |
| Under and above ground .... .... | 3·00 | (0·91) |
| Quarries— | | |
| Inside .... .... | 0·92 | (2·04) |
| Outside .... .... | 0·59 | (0·65) |
| Inside and outside, &c. | 0·81 | (1·55) |

In the coal mines the greater number of deaths were caused by falls of ground; in the metalliferous mines they were caused by shaft accidents. In the former, explosions of fire-damp or coal dust led to 27 deaths only in the total of 1,003, and to 99 injuries only in the total of 106,573.

We have given above the coal output; several other figures of output taken from the report will be found of interest :—bauxite, 9,221 tons (9,589); iron ore, 12,254,195 tons (14,613,032); limestone other than chalk, 9,537,495 tons (10,156,603); manganese ore 12,078 tons (17,456); natural gas, 90,000 cub. ft. (85,000); oil shale, 2,763,875 tons (3,080,867); tin ore, dressed, 5,156 tons (6,378); zinc ore, 6,933 tons (9,025).

---

The Board of Trade has recently issued the following returns of the coal output for the first three quarters of the current year, and the average number of persons employed during each quarter :—

| Quarter ended | Output in tons. | Average number of persons employed. |
|---|---|---|
| March 31, 1920 .... | .... 62,103,000 | 1,188,500 |
| June 30, 1920 .... | .... 58,166,000 | 1,200,300 |
| September 30, 1920 | .... 59,467,000 | 1,207,800 |

The output for the week ended October 9 was 4,713,100 tons.

---

The Ministry of Labour states that on the 1st inst. the average level of retail prices, including those of food, clothing, fuel and light, &c., as well as rents, as indicated by the statistics prepared by the Ministry, was about 164 per cent. above the level of July, 1914. For food alone the average increase was 170 per cent.

---

In our issue for the 1st inst., we dealt with Italian labour, and described the situation which had developed more especially in the industrial districts of North Italy. The Right Hon. George Barnes, M.P., has recently returned from a stay of some weeks' duration in Italy, and his impressions form the subject of a contribution given in a recent issue of *The Times*. From this we take the following statement: "As a condition of the settlement of the recent dispute, the Government has set up a commission of 12 persons equally representative of both sides, with a Government chairman, to examine the industrial question with a view to drawing up a scheme (for embodiment if necessary into law) on the basis of mutuality of control. The workers' claim is for a voice in the determination of conditions of work and full knowledge of profits, purchases, sales, &c. In fact, the Italian industrial situation is working itself out pretty much on the same lines as our own, although approached more from the revolutionary standpoint. Whether the concessions which have been made will be sufficient to keep the peace or not is a matter which only time can tell. It is certain that there is still a good deal of smouldering fire in the working class ranks and, in Milan and Turin, some understanding between the workers on the public services and the turbulent sections of the community."

---

The causes of the labour conflict in Italy may be resumed as follows according to the Fiat Company: Increased wages having been asked for by all the workers in the metal industries, these were refused by the manufacturers on the ground that the general state of the industry did not leave any margin for such an increase. It was pointed out to the workers that these constant increases in wages did not bring any relief, for they only tended still further to increase the cost of commodities. The men received this reply calmly, but immediately started a folded arms strike. When the manufacturers decided to close their shops because of the impossibility of operating them with workers who had decided not to work, the men refused to leave. No force was made use of to evict the workmen, who thus became, for the time being, masters of the whole of the engineering establishments of Italy. When in possession of the factories, the men claimed the right to exercise a control over their management. They maintained that this was the only method by which industrial peace could be secured, for, having a guarantee that they were not being exploited for the benefit of capital, they would submit to a close discipline, and production would be increased. It was at this point that the Italian Government interfered by voting a law under which the workers were given a certain control in the management of the factories. The underlying principle of this was that if the workers were given the opportunity of collaborating with the management in the internal affairs of the factories, they would realise that there are limits which cannot be exceeded without entailing complete destruction, thus the union of capital and labour was likely to have a beneficial effect on economical conditions and national prosperity. At the Fiat factory work has been resumed on this basis, and the old management has again taken command. The new law is about to be applied, and it is hoped and believed that a satisfactory and permanent peace will be obtained

---

Satisfactory news, concerning France, is published in a recent issue of *The Times*, in an article contributed by Mrs. J. Lindon Smith, who has been working since 1915 in the devastated areas in connection with the Franco-American Committee for the Protection of the Children of the Frontier. She says that in the last month she has visited all the Departments directly affected by the war; the destruction of factories took place to an infinitesimal degree in the regions where the factories were in the line of battle, but to an overwhelming degree in the "back areas" in the occupied territory, where a systematic process of destruction was carried out by experts who understood the art of destroying the vital parts of each machine. Agricultural implements also were wantonly destroyed. A hopeful sign is that in every direction one sees that the manufacturer who has lost his factory is determined to rebuild it on absolutely modern lines. The French are facing the lack of coal by having the factories, without exception in the devastated areas, equipped for electric driving; the factories are also being equipped with the best machinery that can be procured. Everywhere there is a shortage of houses for the workmen; there is also a lack of building material, but the people are willing to live in uncomfortable barracks or cellars a little longer in order that in the distribution of building supplies preference may be given to the factories. There was no sign anywhere of any observance of the eight-hour law. The workmen average in one day's work anything from 10 to 14 hours. In factories where they had two eight-hour shifts many of the workmen were working the full 16 hours in order to "get back" that destroyed factory. The French policy has been not to receive a bachelor of foreign nationality, but a foreign articled workman with not less than two children and his wife. Mrs. J. Lindon Smith saw in the Ardennes a group of 200 Austrian families. The Austrian workman throughout got well into his work and got on without discord with his French colleagues. These families will either return to Austria with friendly feelings towards France that nothing will break in the future, or else will remain in a part of France where population is needed and become future citizens of France.

---

Lord Cowdray, Lord Rector of Aberdeen University, in the course of an address which he delivered last Friday, said that the assumption that the worker would necessarily earn a better wage, and have more security and better conditions if he were working for the State than if he were working for a private employer, was an unproven assumption. It presupposed that the total product would be increased if private profit was extinguished, and that the creators, controllers and directors of industry and commerce, the inventors and designers, would do better work for the State, though receiving a less remuneration than they now did. This was an assumption which no impartial person thought of making in regard to the manual labourer, and there was no obvious reason why it should be true of other kinds of workers. But even if we supposed these obstacles overcome, none of the socialistic schemes put forward attempted to solve the problem of the remuneration of Labour. The transfer of the controlling and directing functions from one set of individuals, called employers and capitalists, to another set of individuals, called the State, left the question of the division of the product untouched. The wage-earners held tenaciously to the position that they would not forego their right to strike, whether the State or the private employer was controller. In Lord Cowdray's view, the hope of the country lay in the substitution of the idea of partnership for the idea of class war. The partnership, unfortunately, could not be on equal terms, since men were not equal either in hands or in brains. There were three factors in the "ideal wage": (1) the guaranteed minimum; (2) a variable quantity according to the output of the individual; (3) a variable addition according to the result of the undertaking. In short, it was piece-work together with a guaranteed minimum and a bonus on profits. This, if realised, would secure the worker against falling below the poverty line, put a premium on his individual effort, and give him an interest in the results of his labour. Some trade unions were active in their endeavours to kill all piece-work. This they could not be allowed to do. Without piece-work few industries in this country could permanently flourish.

---

Since our last issue the railwaymen issued an ultimatum threatening to come out on strike at midnight on Sunday, the 24th inst., with a view to uphold the miners' claims. This decision on the part of the railwaymen was made known late on Thursday, the 21st inst., and on the same day it was referred to in Parliament, the Prime Minister stating that it had embarrassed the negotiations which had been proceeding for the last few days. "It had not been merely an embarrassment to one party," he added, "but to both parties. It was an interference which was exceedingly rash, exceedingly indiscreet and precipitate, and I cannot find that it was desired by anybody." Following this, further meetings of the railwaymen were held, and, on Saturday afternoon, the 23rd inst., Mr. J. H. Thomas announced the suspension of the threatened railway strike. He said: "The railway delegate meeting, acting on the advice of the Miners' Federation, have decided to suspend indefinitely the strike notices issued to the members, pending the negotiations between the Government and the miners, with the view of giving every opportunity of effecting an honourable settlement." Speaking for himself, Mr. Thomas said he not only welcomed the decision, but also the fact that negotiations were being resumed. The miners by their action, he added, had given another clear indication of their anxiety for peace.

---

The Government has been unremitting in its endeavours to promote a settlement of the coal dispute, conversations and meetings having been held constantly since the dispute commenced. It was hoped on Wednesday that an agreement satisfactory to all parties had been reached, Mr. Evan Williams of the

Coalowners' Association having obtained from the association their complete approval of the pledge he had given the Government with reference to co-operation for increasing output and the providing of machinery to further increase in output. The miners, it was understood, had agreed, on their part, to their receiving the 2*s.*, 1*s.*, and 9*d.* advances per shift provisionally (until a National Wages Board had agreed upon a wages scheme), and on conditions which took into account both output and the cost of living. The said advances during the provisional period were not to entail any increase in the price of coal. The National Wages Board was to be formed with as little delay as possible, and it was to deal with the future regulation of wages and to determine the manner in which the revenue from coal was to be allotted. It was hoped that the above conditions would be agreed upon finally; in the meantime, however, their acceptance by the miners is in abeyance, since at a late hour yesterday they came forward with fresh demands: they now claim that if the output during the provisional period, for which the advance in wages is to be granted immediately, exceeds the estimate of output, a further advance is to be given them immediately also, and this quite apart from any decision of the National Wages Board, which Board, it is reported, can only be formed and be ready to commence working in two or three months time. The allotment of the surplus proceeding from increased output appears also to have come up afresh for discussion, as also has the length of the provisional period. Discussions are proceeding still, and no final decision was reached at the time we went to press.

## THE LATE MR. WILLIAM MELVILLE, C.B.E.

We regret to have to announce the death, which occurred on the 21st inst., at Northcote, Hillfoot, Bearsden, of Mr. William Melville, C.B.E., chief engineer of the Glasgow and South-Western Railway, a position from which he retired on October 31, 1916. He was a member of the Institution of Civil Engineers since March, 1893. Mr. Melville was born on September 18, 1850, at Dunoon, where his father was at one time Provost; he went to Glasgow as a lad where, from 1866 to 1868 he worked in the carpentry trade. In the latter year he entered the service of the North British Railway Company, where he remained down to 1874, five years of which time he served as a pupil under the engineer-in-chief, Mr. James Bell. From 1874 to 1882 Mr. Melville acted as chief assistant to Mr. James Carswell, engineer for the Western Division of the above railway. He was, later, appointed engineer-in-chief of the company.

During the period of his service as a railway engineer, Mr. Melville carried out a very large amount of work for the various railways with which he was connected. For the North British Railway, as chief assistant engineer in Glasgow, he had charge of the enlargement of Queen-street passenger and goods stations and grain stores. He also had charge of the new Craigendoran railway and pier near Helensburgh; of the widening of the line between Helensburgh and Cardross, and also of part of the Airdrie and Bathgate line; the breakwater and timber wharfing at Port Edgar, near Queensferry, on the Firth; the construction of Cowlairs West loop line, Glasgow; the Benhar branch railway and the Bowhouse branch railway. New carriage and wagon shops at Cowlairs were also carried out by him.

When acting for the Caledonian Railway, Mr. Melville executed important work on the Glasgow lines from Dalmarnock to St. Rollox; he also had charge of the widening of the line from Central Station to Eglinton-street Station, Glasgow. We may also mention the Gourock Railway and Pier; the railway to James Watt Dock, Greenock, and the Bonnybridge branch railway. While engaged with the Caledonian Railway, Mr. Melville also prepared a number of working drawings for important lines, some of which were built at a later date.

Mr. Melville's most important work, however, was done for the Glasgow and South-Western Railway. Included in this may be mentioned the widening of the City Union lines, Glasgow, which comprised the demolition of the old viaduct carrying the railway over the Clyde and the substitution therefor of a new viaduct carrying four lines of rails on the site of the old viaduct. This widening swept away the whole of the bridges carrying the railway over the streets, and entirely new structures were built to suit the widened lines. These bridges varied in span from 60 ft. to 130 ft. He extended St. Enoch Station, Glasgow, adding six new platforms to the six of the original station. He also had charge of the Bridgeton Cross underground line, Glasgow; the extension of the line to Darvel; the Dalry and North Johnstone railway and widening at Dalry; the Gateshead and Hurlford railway; the Riccarton loop line near Kilmarnock; the railway from Paisley to Barrhead; the railway viaduct over the River Ayr at Ayr Harbour; the Catrine branch railway; the Moniaive light railway; the Turnberry light railway from Ayr to Girvan. Mr. Melville also carried out the widening of the Maybole and Girvan line between Ayr and Girvan; the widening between Dalry and Kilwinning, and the Eldersl1e widening, both these to four lines of rails. The company, in 1892, purchased the Ayrshire and Wigtownshire railway, but the conditions of the permanent-way were such at that time that it was necessary partly to reconstruct the whole line, 31 miles in length, and relay it with the standard permanent-way of the Glasgow and South-Western Railway. He, further, had charge of building the new station at Princes Pier, Greenock, and of the extension of the line there; of the reconstruction of the pier; the deepening of the graving dock, and the construction of new entrance gates, Troon Harbour; also of new carriage and wagon shops for the Locomotive Department at Barassie. When Mr. Melville joined the Glasgow and South-Western Railway about twenty-nine years ago, the company's engine shed accommodation was somewhat limited, and new engine sheds with modern coaling arrangements were built at Corkerhill, on the outskirts of Glasgow. At this place the company have built a large number of dwelling houses, and at present there is a colony of the company's employees of the Locomotive Department resident there. New engine sheds and other accommodation were also built at Ardrossan and Carlisle. At the latter place the company also built a superior class of houses for the employees in connection with the Locomotive Department. Large carriage sheds have also been constructed at Bellahouston and Gorbals, Glasgow. The company further constructed an esplanade on the foreshore at Ayr to enclose a large amount of land which they purchased between the railway and the sea, including a concrete sea wall with carriage drive and promenade footpath.

In 1891, when Mr. Melville joined the Glasgow and South-Western Railway, the permanent-way was mostly built of 76-lb. and 80-lb. per yard rails; 90-lb. rails, however, had been introduced shortly before that time, and are now the standard section of the whole system. The rails have also been lengthened since then from 30 ft. to 45 ft., and the permanent way otherwise considerably strengthened.

Mr. Melville also acted as joint engineer with the Caledonian engineer on the extension of the Stranraer harbour pier, in Loch Ryan, for the Portpatrick and Wigtownshire Joint Railways. While acting as engineer-in-chief for the Glasgow and South-Western Railway, he acted as engineer for the Glasgow, Barrhead and Kilmarnock Joint Railway, and as engineer for the Portpatrick and Wigtownshire Joint Railways every alternate three years with the Caledonian engineer.

## NOTES ON NEW BOOKS.

The many thousands of users of Ford cars in this country will doubtless appreciate the publication recently issued by Mr. R. T. Nicholson, M.A., the object of which is to show "how Ford owners can get the best out of their cars," and to "ensure the running of a simple and easily-controlled car with economy and efficiency." It is entitled "*The Book of the Ford*," and contains detailed illustrated instructions on the working of the car, on all the main and auxiliary mechanical parts, adjustments, replacements and so forth. Reference to every detail dealt with is facilitated by a most complete index. The book, which now is in its fifth edition, will be found a most adequate guide. It is published at the price of 3*s.* net by the Temple Press, Limited, 7 to 15, Rosebery-avenue, E.C. 1.

When an author is limited, or limits himself, to 106 pages in writing on modern explosives, he might adhere to his subject and give the reader the benefit of "the exceptional opportunities afforded to him to gain comparative knowledge of the methods of manufacture, adopted not only in all the Allied countries, but also in Germany," instead of laying stress on the absolute interdependence of all modern industry and on chemistry and national welfare. Yet this is largely what has been done in the "*Modern Explosives*" of Mr. S. I. Levy, B.A. (Cantab.), B.Sc. (Lond.), F.I.C. [London: Sir Isaac Pitman & Sons, Limited, 3*s.* bound]. There are a few views of explosive works. There are no diagrams, there is not a single formula and literature references are totally absent likewise. Yet the book is certainly readable, and it will interest the general reader, but we underline the adjective.

A book which is "a compilation of facts, figures and formulæ bearing on the everyday work of an irrigation engineer," is sure to be welcome to the latter. Such is the "*Irrigation Pocket Book*," by Mr. R. B. Buckley, C.S.I., late chief engineer, Indian Irrigation Department, published at the price of 30*s.* net by Messrs. E. and F. N. Spon, Limited, 57, Haymarket, S.W. 1. It measures 7¼ in. by 5¼ in. and contains 625 pages of carefully indexed and closely but most clearly printed information on the subject of reservoir construction and irrigation in all its branches, compiled by an engineer who acquired great experience on the subject during a lengthy period of service in India. The data given do not deal with the case of India alone and are not applicable to that Empire alone; they cover work carried out in other parts of the world, and are of general practical application. The construction of barrages, dams and embankments, the subjects of concrete, reinforced concrete, masonry work, foundations, and other allied subjects are entered into in detail.

The steadily increasing popularity of the slide rule has created a demand for a simple and clearly written explanation of its construction and use. This need is well met by the pamphlet on "*Slide Rules and How to Use Them*," compiled by Mr. T. Jackson, M.I.Mech.E., and published by Chapman & Hall, Limited, price 1*s.* 6*d.* net. The bulk of the paper is mainly devoted to the discussion of the Gravet type of rule, which is that in most common use, but log-log rules are also adequately described as also a number of special rules. These are no doubt advantageous when in constant use for making the particular class of computation for which they are designed, but if used but occasionally it commonly takes longer to learn the rule afresh each time than to obtain the result with the common type of rule, although a more complicated procedure may be necessary than with the special rule.

It took a Mendelssohn to provide us with "Songs without words," but the purveyors of "Words without thought" are numerous, and with us always. A notable example of this deplorable type of literature is "*Guild Socialism Re-stated*" by Mr. G. D. H. Cole, which is issued at 6*s.* net by Mr. Leonard Parsons. The author is an exponent of the methods of the Mediæval School, men who held that they could arrive at truth on all matters of science, religion and philosophy simply by mere logic, and that it was quite unnecessary to compare their deductions with experience. There is hardly a page on which Mr. Cole does not make serious misstatements of fact, due to his mistaking his misconceptions for actualities. He talks of the workers as a dispossessed class. It would have been more to the point to show, for example, what workers were dispossessed by Mr. Henry Ford or Lord Leverhulme. In fact, it is notorious that these men have increased and not diminished the possessions of those they employ. Again, Mr. Cole complains that the whole value of the "workman's product" over and above his wages is absorbed by others. He makes no attempt to show, however, on the average and on normal conditions, that the workman does produce any surplus not represented by his wages. The value of the final product is only partially due to the workman, whose work may be excellent and yet the final product may be without value. Indeed, so far as intrinsic values are concerned, this fact is well illustrated by the book under review, the printing of which is excellent. The same holds true as regards exchangeable values. Thus a mechanic employed in experimenting on a perpetual motion machine will receive in wages far more than the value of the joint product of himself and the mind that directs him. On the other hand, had he been employed in developing the steam turbine, he would rightly and properly receive far less for his share of the work than the value of the machine which he had produced under the direction of the mind which had the genius to conceive and the courage to face the heavy financial losses involved in exploiting the blind alleys into which every great inventor must at times stray before he finds the true line of progress. All history shows that mind is the main factor in the creation of wealth, and that no syndicate of mediocre minds can replace the exceptional one. Genius is essentially individualist as Emerson pointed out 70 years or more ago.

Oil-Fuel Fired Steam Lorry.—A 5-ton Foden steam wagon belonging to Messrs. Yorke, Stoneham and Jones, has, we understand, been running successfully for about six weeks fired by oil fuel on the system of the Scarab Oil Burning Company, Limited, 28, Charles-street, Haymarket, S.W. 1. This system, of which we gave an account recently in our columns, as fitted to a locomotive, has to be slightly modified for steam wagons, to ensure ease of starting up. Two burners are fitted in the Foden wagon, and a hand pump is provided for blowing one burner with air until an atomiser coil is heated. This coil is placed in the path of the flame, and when hot is supplied with water which, of course, it transforms into steam. As soon as steam is produced—*i.e.*, in about 5 minutes—the hand pump is cut out and the one burner continued on this steam until sufficient is generated to feed both burners when the second is lighted. As soon as from 10 lb. to 15 lb. are raised in the boiler, the water fed to the atomiser coil is stopped, and the coil withdrawn, and the burners are turned over to boiler steam. The burners use about ½ a gallon of oil per mile.

# 60-TON ELECTRIC OVERHEAD TRAVELLING FORGE CRANE.

CONSTRUCTED BY SIR WILLIAM ARROL AND CO., LIMITED, ENGINEERS, GLASGOW.

*Fig. 1.*

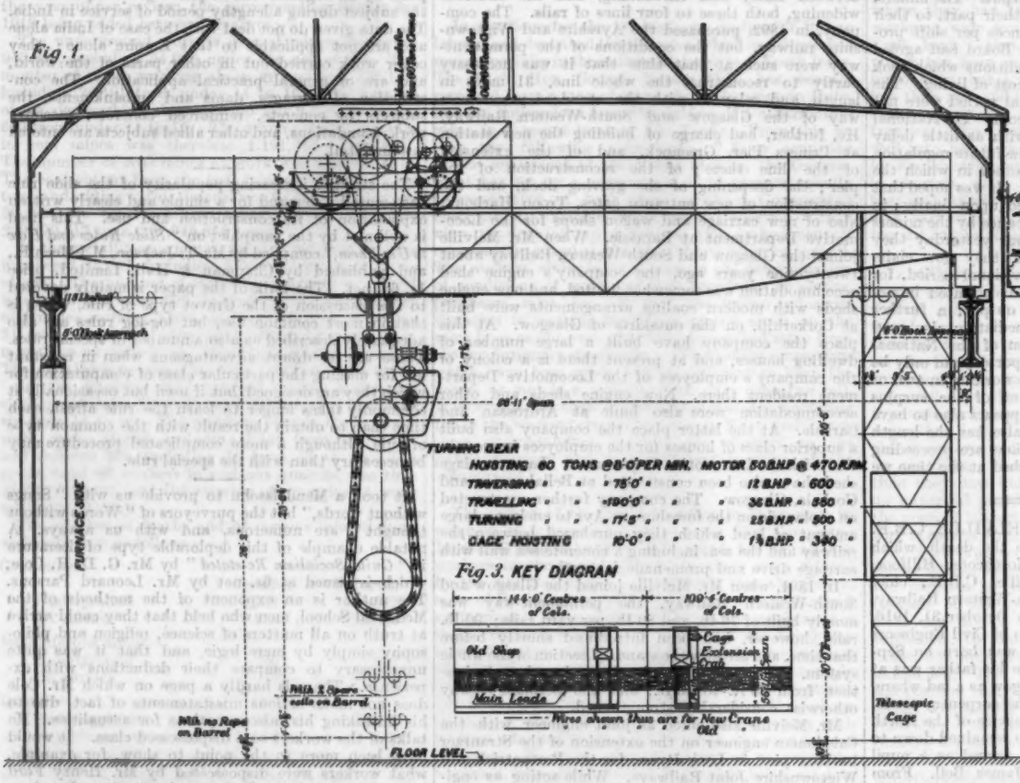
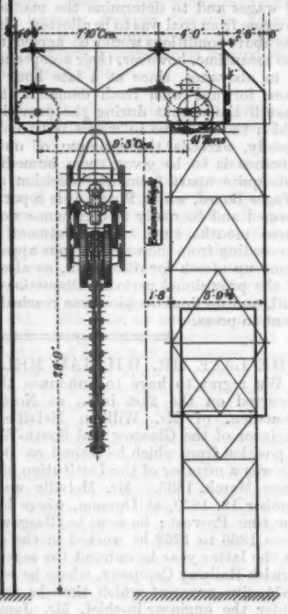

TURNING GEAR
HOISTING 60 TONS @ 8'0" PER MIN. MOTOR 50 B.H.P. @ 470 R.P.M.
TRAVERSING " " 75'0" " " 12 B.H.P. " 600 "
TRAVELLING " " 190'0" " " 36 B.H.P. " 550 "
TURNING " " 17'5" " " 25 B.H.P. " 500 "
CAGE HOISTING 10'0" " " 1½ B.H.P. " 340 "
Fig. 3. KEY DIAGRAM
144'6" Centres of Cols.
100'4" Centres of Cols.
Old Shop
Cage Extension Crab
Main Leads
Wires shown thus are for New Crane
Old
Telescopic Cage
FURNACE SIDE
FLOOR LEVEL

*Fig. 2.*



A SIXTY-TON overhead forge crane constructed by Sir William Arrol and Co., Limited, Parkhead, Glasgow, for the Dennystown Forge Company, Dumbarton, is illustrated above and on pages 573 and 576. This crane has a span of 56 ft. 11 in. and height from floor to rail level of 28 ft. 9 in. The current is direct current at 220 volts, the motors being of the totally-enclosed series reversing type. With a load of 60 tons, the hoisting motor of 50 brake horse power running at 470 r.p.m., gives a lift of 8 ft. per minute. With the same load the traversing speed is 75 ft. per minute, the motor for this being of 12 brake horse power running at 600 r.p.m. The travelling speed with full load is 190 ft. per minute., the motor for this motion being one developing 36 brake horse-power at 550 r.p.m.

Our illustrations give a very good idea of this crane, Figs. 1 and 2 being end and side elevations, while Fig. 3 is a diagram of the electric leads overhead. Fig. 4, page 573, is a view of the ingot-rotating gear, and Fig. 5 is a view of the cage, which is telescopic. Fig. 6, page 576, is an illustration of the crane in the forge of the Dennystown Forge Company. The hook normally lowers to within 4 ft. of the ground level, but if all the rope is run off the barrel it can be lowered to about 1 ft. 6 in. of the floor. The cage is contained in a telescopic structure, the rigid portion of which terminates almost 11 ft. above the floor, while the telescopic portion can be lowered to within a foot of the ground. The moving cage is operated by a 1½-h.p. series-wound motor, through worm and spur reduction gears driving a pulley on which the rope is coiled. The hoisting rope is anchored at one end to the rigid structure of the crane above. The other end is led from the cage pulley over guide pulleys above to a balance-weight moving in channel guides, as seen in Fig. 5. This arrangement of telescopic cage allows the operator easy access to the crane, and also enables the man to work from a position giving a good view of the press when forging. The cage hoisting speed is 10 ft. per minute, the motor running at 340 r.p.m.

The controllers are of the drum reversing type, rated 20 per cent. in excess of the size of the motors. The hoisting motion is fitted with a self-resetting limit switch to prevent overwinding. An automatic solenoid brake is fitted to the hoisting motor spindle, operated by a solenoid magnet in such a way that the brake is released as soon as the motor is started, and applied as soon as the motor is stopped, or fails for any reason. An automatic centrifugal brake controls the speed when lowering. In order to prevent the crane being overloaded by the action of the press the solenoid brake is released if an overload occurs, and the hook is allowed to lower out until the load on the crane returns to normal, when the brake is automatically reset.

The ingot rotating gear suspended from the crane double hook is worked by a 25-h.p. motor running at 500 r.p.m., giving a speed measured at the periphery of the drum of 17·5 ft. per minute. The chain drum consists of a steel casting with sprocket teeth on the flanges gearing with projecting pins on the chain. The drum is driven by the motor by worm and spur reduction gears, the worm and worm wheel running in an oil bath, with ball bearings fitted to the worm spindle. Current for the turning gear is taken from a junction-box on the crane, by a flexible cable winding on to a spring-operated drum fixed to the crab.

## NITROCELLULOSE.*

By Sir R. ROBERTSON, K.B.E., F.R.S.

*Introduction.*—The principal applications of nitrocellulose in industry are to celluloid, propellants, artificial silk, collodion and some blasting explosives. In this paper I shall confine myself for the most part to nitrocellulose as used in the manufacture of propellants, and I propose to describe some of the relations that exist between the solutions of cellulose and of nitrocellulose and the gelatinised nitrocellulose after the solvent has been eliminated, together with some work on the characteristics of its solutions.

Most of the modern propellants are colloidal in character, and it is to the nitrocellulose which they contain that this character is to be attributed. As they have no definite crystalline structure, and can be obtained as uniform non-porous masses by the process of incorporation or malaxation during manufacture, they present an unbroken surface to the flame which ignites them, and even under pressure continue to burn regularly from layer to layer. It is this property that has enabled guns to be designed much lighter in weight than for gunpowder, and that has made it possible by suitable choice of thickness of the propellant to secure very high velocities of projectiles (within a narrow margin of a few feet per second from round to round) without undue strain on the gun.

To obtain the degree of regularity in ballistics necessary for accurate shooting it is important for the dimensions of the finished propellant to be within very narrow limits. It has been found that the nature of the nitrocellulose used affects the amount of shrinkage which takes place in the cord after squirting from the die, and it is obvious, therefore, that the colloidal properties of nitrocellulose gelatinised by means of solvents, either volatile or non-volatile, are of great importance in the study of propellants.

I propose to bring to your attention the results of some work on gelatinised nitrocellulose that has been carried out at the Royal Gunpowder Factory, and the Research Department, Woolwich.

Among the more important aspects that have to be considered are the influence on the product of the nature of the raw material, the influence of the process which it undergoes in being nitrated and stabilised by boiling with water, and the effect of these on the characteristics of the finished material. Among other important properties the viscosity of solutions of cellulose and of nitrocellulose in relation to these aspects clearly required investigation.

*Treatments which Affect the Viscosity of Cellulose and Nitrocellulose Solutions.*—In general, those treatments which would be expected to effect disruption of molecular aggregates (*e.g.*, by grinding or chemical decomposition such as hydrolysis) are found to lower the viscosity both of cellulose and nitrocellulose solutions.

The treatment of the cellulose before solution, with bleaching powder (oxidation) or caustic soda (hydrolysis) in the usual processes of cleaning, reduces the viscosity of its solution in cuprammonium. The viscosity of the solution itself is reduced by exposure to air or light, or even to some extent by simply allowing it to stand for some time. The viscosity of the solution of the corresponding nitrocellulose is found to be affected in the same direction.

With the nitrocellulose, the steam boiling treatments given in the purification process lower its viscosity, but there appears to be a practical limit to the process. When the more easily attacked forms of nitrocellulose have all been destroyed by boiling, the further reduction in viscosity is very slow, and if the cellulose before nitration has been treated so as to reduce its viscosity markedly, no great reduction of viscosity is produced by boiling the nitrocellulose.

In order to produce a nitrocellulose of low viscosity, it is found to be better to reduce the viscosity of the cellulose as far as possible by suitable treatments than to rely on the reduction during boiling of the nitrated product.

*Relation of Viscosity of Solution and of its Nature to the Toughness of the Dried Nitrocellulose Colloid.*—In some earlier work the viscosity was measured by means of a viscosimeter of a simple type, and the toughness of the resulting gelatinised dried nitrocellulose in the form of cord was evaluated by determining the least radius of curvature to which the cord could be bent. This method brought out such differences as that a cord of nitrocellulose of 13 per cent. nitrogen content cracked

* Paper (abridged) contributed to the general discussion on "Colloids," before the Faraday Society and the Physical Society, London, October 28.

# 60-TON ELECTRIC OVERHEAD TRAVELLING FORGE CRANE.

CONSTRUCTED BY SIR WILLIAM ARROL AND CO., LIMITED, ENGINEERS, GLASGOW.

(*For Description, see opposite Page.*)

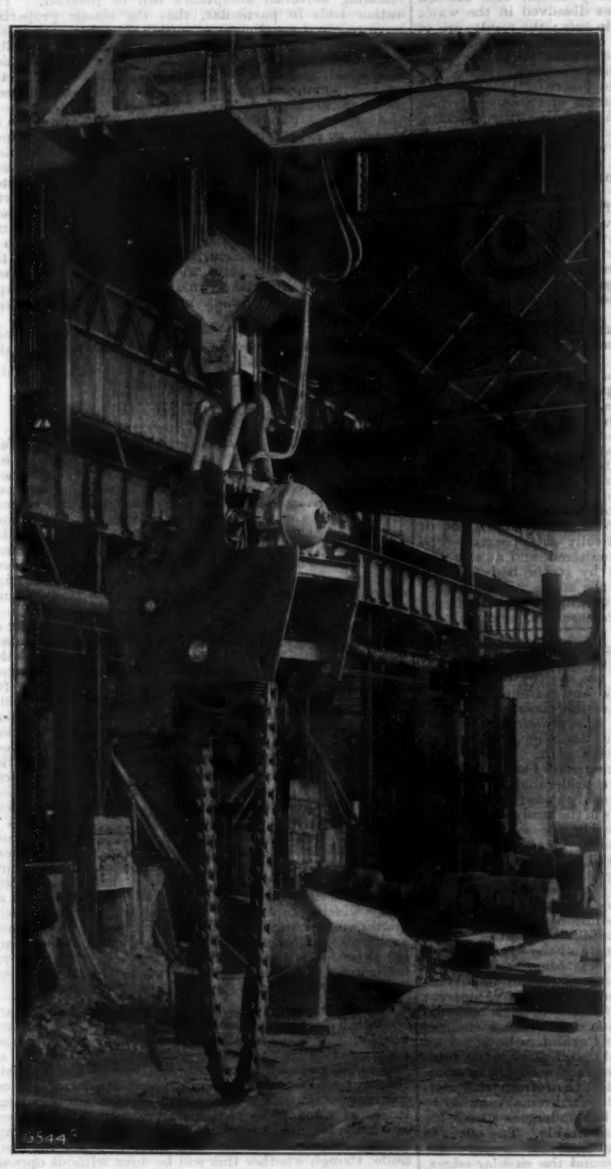


FIG. 4. INGOT ROTATING GEAR.

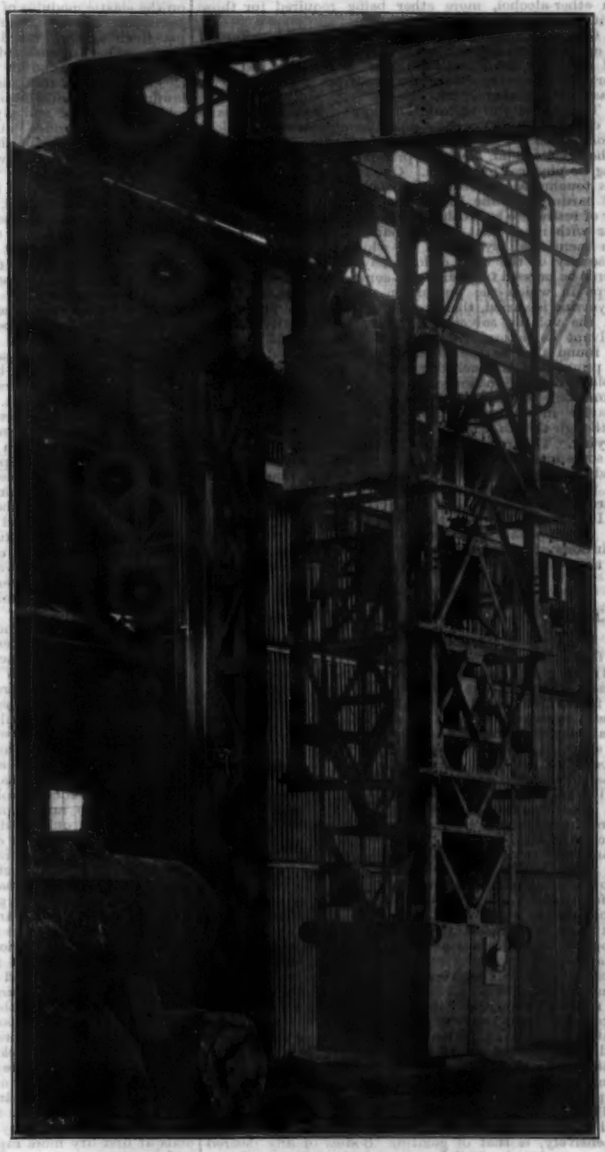


FIG. 5. TELESCOPIC CAGE.

at a radius of curvature of 100 mm. when acetone had been the solvent, while a cord of nitrocellulose of 12·4 per cent. of nitrogen broke at a radius of 25 mm. again with acetone as the solvent, and at 5 mm. when ether-alcohol had been used to gelatinise it.

From the results of these experiments it was deduced that when the same simple solvent (acetone) was used to gelatinise nitrocelluloses of a high nitrogen content (13 per cent.) the viscosity of the nitrocellulose solution was inversely proportional to the toughness of the resulting cord. The coherence of the dried nitrocellulose was thus found to be adversely affected by the higher state of aggregation of the molecules of the nitrocellulose, as indicated by the viscosity of its solution. This short note on these experiments has been given, as they illustrate a connection between the viscosity of a solution and the physical consistency of the dried nitrocellulose.

The nature of the volatile solvent also affects the brittleness of the dried gelatinised substance. Thus the dried product made by gelatinising nitrocellulose of 12·4 per cent. nitrogen with ether-alcohol is much tougher than that gelatinised with acetone, and a similar effect is obtained by adding some alcohol to the solvent acetone. Caution has, however, to be observed in this connection, as retention of the solvent in an imperfectly dried substance may give a quite fictitious semblance of toughness to a film of gelatinised nitrocellulose.

*Processes for Determining the Viscosity of Cellulose and of Nitrocellulose Solutions.*—It might now be well to refer to some of the methods that have more recently been found most suitable for determining the viscosity of solutions of cellulose and nitrocellulose, and to state briefly the information that study of this property has afforded. Of great importance in this connection has been the application of the falling sphere viscosimeter, in which the velocity is observed of a steel ball, 0·15 cm. in diameter, under standardised conditions, falling through the solution, appropriate corrections being made for deviations from Stokes' law on account of the side-effect of the walls and the end-effect of the bottom of the viscosimeter tube. This instrument has had a wide application in the study of solutions of nitrocellulose, and the difficulties inherent in its application to solutions of cellulose in cuprammonium solution, chiefly on account of the need for eliminating air in this estimation, have been overcome (Gibson, Jacobs, Spencer and McCall, J. Chem. Soc., 1920, 117, 472, 484).

For cellulose dissolved in cuprammonium solution a capillary viscosimeter in which the solution comes into contact only with hydrogen was developed.

The subject of the viscosity of cellulose and of solutions of cellulose was further pursued at the Research Department, Woolwich, by the application of the methods of determining viscosity mentioned above, and some of the results obtained in these investigations may now be considered.

*Viscosity of Cellulose Solutions and their Relation to Nitrocellulose Solutions.*—In the first place, as regards the cellulose itself, the reduction in its viscosity brought about by increase in temperature of the alkaline pressure boiling to which the cotton is subjected, and the influence of increase in the concentration of the caustic alkali in this process in the same direction have been described by Gibson (*l.c.* p. 481).

Correlations were then made between the viscosity of the cellulose in cuprammonium solution and that of the solution in ether-alcohol of the nitrocellulose made from it, and it was established that although the processes of nitration and stabilising by boiling of the nitrocellulose tended to level down differences, yet there is a general relationship in the sense of higher viscosity of the nitrocellulose made from cellulose of high viscosity, and it was brought out that if the cotton had been incompletely reduced in viscosity by the soda boiling, the viscosity of the finally purified nitrocellulose was with greater difficulty brought down by the steaming during stabilisation.

*Minimum Viscosity of Nitrocellulose Solutions.*—The viscosity of solutions of nitrocellulose in ether-alcohol was then studied (see Gibson and McCall, J. Soc. Chem.

Ind. 1920, 39, 172, T) by the method of the falling sphere viscosimeter, and it was established that there was a minimum viscosity at a certain proportion of ether to alcohol, solutions on either side of the minimum being more viscous, and indeed forming jellies with the higher proportions of either alcohol or ether. The position of this minimum was also found to be independent of concentration, but to vary with nitrogen content among those nitrocelluloses which are soluble in ether-alcohol, more ether being required for those with the higher content of nitrogen.

*Concluding Remarks.*—The above work has afforded a great deal of information on the nature of the solution of cellulose and of nitrocellulose and forms the basis for theoretical speculation apart from the bearing it has had on manufacture.

The viscosity of the solutions has been proved to have a direct relation to the properties of the dried colloid from which the solvents have been eliminated by drying. The dried colloid, however, presents difficulties in assessing its physical properties. One method of determining its toughness has been mentioned, and determinations of hardness by the Brinell method, of breaking strain, or of resistance to crushing have been applied, but not so far with much that is informative. One method may be mentioned by means of which variations in the viscosity of the hard colloid may be traced. If large cords be pressed from different composition of the cordite type in which the proportion of guncotton to nitroglycerine is varied, these cords retain a small proportion of the volatile solvent. If now the quantity of this solvent be determined in different concentric zones it is found that as the nitrocellulose becomes dominant, a proportion is reached when the distribution of the volatile matter is no longer uniform but increases regularly from skin to core, the ratio of the content of volatile matter in the different regions remaining constant although the total quantity is reduced in the process of drying. This resistance to the migration of the solvent is some measure of the viscosity of the horny substance, and its regional determination might, perhaps, assist in the investigation of the physical condition of other hard colloids.

It is hoped that the above will show the importance of the application of the investigation of the colloid solutions of nitrocellulose and indicate, perhaps, points of theoretical interest that remain to be followed up.

## THE PROPERTIES OF ELASTIC GELS.*

By Emil Hatschek, F.Inst.P.

The statement that the familiar table jellies (gelatin gel) are typical representatives of the class to be discussed in the present paper will probably, at the outset, be found more useful than an attempt at strict definition. These systems exhibit immediately two of the most characteristic properties of the elastic gel: stability of shape, notwithstanding a very high content of liquid (about 95 per cent. in the case quoted) and perfect elasticity within certain narrow limits.

The gel may be obtained in two opposite ways: either by transformation—which may be reversible or irreversible—of a sol, *e.g.*, by cooling a gelatin sol below a certain temperature; or by allowing the dry substance to "swell" in an appropriate liquid. Practically, all substances from which elastic gels may be produced show this capacity of swelling, though to an extent which differs widely. Only certain liquids will cause a given substance to swell, and the relations between the constitution of the solid and the liquid, on which this property is based, are at present quite obscure. Thus gelatin and agar (the former a protein, the latter a mixture of carbohydrates) swell in water at ordinary temperature, but do not dissolve until the temperature is raised. Vulcanised india-rubber swells in various organic solvents such as benzene, toluene or Xylene, without dissolving. Finally, the processes of swelling and dispersion or solution may proceed *pari passu*, as with gum arabic at ordinary temperature. At low temperature, a definite stage of swelling may be observed to precede solution.

The elastic gel which can be most easily reproduced and has, accordingly, been studied most frequently and extensively, is that of gelatin. Bodies of any desired shape can be obtained by pouring the gelatin sol into suitable moulds and allowing it to set for a period of not less than 24 hours (*cf. infra*, E. Fraas). The procedure, once chosen, must be rigidly adhered to throughout, since all the properties of a gel depend, not only on its composition, but also to a marked extent on its history, especially its "thermal history," *i.e.*, the temperatures to which the sol has been exposed and the duration of such exposure. Some of the principal investigations will now be briefly summarised.

*Elastic Properties.*—These have been studied principally by R. Maurer, P. v. Bjerken, E. Fraas and A. Leick. All these investigations date back some time, and were undertaken with a view to studying a material with very low modulus and sufficiently transparent for examination in polarised light, rather than with the intention of elucidating such problems as the structure of gels. Both Maurer and Leick determined Poisson's ratio for gels of various concentrations and find it 0·5 within the limits of error—a result which is not surprising in view of the large percentage of liquid. Leick found the modulus E roughly proportional to the square of the gelatin concentration; the ratio $E/c^2$, however, varies somewhat irregularly, and decreases with increasing c. All the investigators find that the modulus increases with increasing load.

Fraas studied the ageing of gels and found that a constant modulus was not reached until about 24 hours after apparently complete setting. These hysteresis effects are universal in colloidal systems, and the increasing modulus of a gel is paralleled by the increasing viscosity of the sol, when kept at a temperature above the setting point.

Maurer, and more particularly Leick, also studied the effect of various substances dissolved in the water on the elastic modulus of gelatin gels; the results are of particular interest from the colloidal point of view, inasmuch as they can be co-ordinated with the well-known effects of such solutes on other properties of the system, *e.g.*, maximum swelling, setting point of sol, &c. Leick finds that the addition of various chlorides lowers the modulus, sodium sulphate is without action, while cane sugar and glycerine raise the modulus considerably. Chlorides also lower the viscosity and setting temperature of the sol, while glycerine and cane sugar (generally substances containing hydroxyl groups) raise both constants.

The elasticity of gels is perfect only for small loads applied for a short time, but very little work has been done on relaxation in such systems. R. O. Rankine* maintained gelatin gels of low concentrations (3·4 per cent. to 4·5 per cent.) at constant strain and plotted the stress necessary to do this against time. The stress, within the limits of concentration and time investigated never becomes zero.

Reiger† determined the relaxation time of gelatin gels by optical means (disappearance of the double refraction produced by strain).

That the conditions are entirely different at lower temperatures is shown by experiments by the writer, published here for the first time. Rectangular prisms of gelatin gel (10 per cent.) with 1 per cent. of sodium fluoride, to prevent putrefaction, were cast and allowed to set 36 hours before removal from the mould. One of these prisms was then bent between three stops fixed on a glass plate. The specimen was then photographed in polarised light (double plate glass as polariser, Nicol as analyser) within 10 minutes of the application of stress at room temperature, about 15 deg. C. At the end of five days the stress had practically disappeared. The appearance was substantially unaltered, and at any rate the optical anisotropy caused by strain had not disappeared with the removal of the stress. The absence of relaxation in a system consisting to about 90 per cent. of liquid is certainly remarkable, and will be referred to again.

On the whole, our knowledge of the elastic and the related optical properties of gels must be pronounced slight. As in other branches of the subject, non-aqueous systems have received hardly any attention; their study is eminently desirable, as the enormous complications introduced in the case of a protein like gelatin by the formation of salts, and their electrolytic and hydrolytic dissociation, would be absent.

*Diffusion in Gels.*—This phenomenon has, for various obvious reasons, received a considerable amount of attention. Thos. Graham already used dilute gel, instead of pure aqueous solutions in the study of diffusion, and found the rate approximately the same in both. This, however, only holds good of gelatin gels up to, say, 3 per cent. or 4 per cent. and agar gels under 1 per cent. In more concentrated gels the rate of diffusion decreases markedly with the concentration, but no quantitative relations have, so far, been determined. The rate of diffusion for a given solution and gel concentration can be affected by various solutes in the latter.

The fact that both the swelling and the drying of gels are controlled by diffusion involves some consequences which, considering that they may have an important bearing on histology and related subjects, have not yet received adequate attention. If a body of gel is bounded by a surface in which the radius of curvature changes very quickly or (as in polyhedra cylinders bounded by plane ends, &c.) discontinuously, diffusion to or from regions adjacent to tracks of surface with low or zero-radius takes place more rapidly than from the rest. The result is that a body of gel does not remain similar to itself during swelling or drying, but undergoes successive deformations which may be considerable. The effect is particularly marked in drying: thus, cylinders with plane ends at first dry more rapidly round the circular edges, which contract, the profile becoming that of a barrel with convex ends. As the material forming the edges becomes less permeable, the large surfaces dry more quickly, and the final shape is, approximately, a single-shell hyperboloid with concave ends. On allowing such a body of dry gel to swell again, the original shape is not necessarily restored; the reason for this alteration in the capacity of absorbing water is obscure.

The foregoing summary—though necessarily restricted by considerations of space—may give the reader unfamiliar with the literature some idea of our present knowledge. The two great problems to be solved must now be set forth briefly. They are (1) the elucidation of the structure of elastic gels, and (2) the explanation of the phenomenon of swelling. As regards the former, there is at present a fundamental divergence of opinion, inasmuch as some authors (H. Procter, W. Pauli and J. R. Katz) maintain that elastic gels are homogeneous systems, *i.e.*, solid or (H. Procter) "semi-solid" solutions. The evidence for this view is set forth at length in a very exhaustive monograph by Katz. The other school (W. B. Hardy, Wi. Ostwald, Wo. Ostwald, S. C. Bradford, Dorothy J. Lloyd) consider gels to be heterogeneous systems, but differ regarding the state of aggregation of the phases. Wi. Ostwald, in particular, considers gels to be systems of two liquid phases having an interfacial tension, while some of the other investigators incline to the view that the properties of gels are best accounted for by assuming some sort of network or cellular arrangement of solid phase permeated by liquid. Speaking generally, these rival theories are based on the consideration of a limited number of selected properties, and a great deal of further work is required, probably on quite novel lines, before a definite conclusion commanding universal acceptance can be reached. The author feels in particular, that the elastic properties have received insufficient attention, and has attempted, as a first step, to examine whether they are compatible with the assumption of two liquid phases possessing interfacial tension, the result being negative if the assumptions necessary to allow of mathematical treatment are granted.

As regards the phenomenon of swelling, we have at present no explanation whatever why certain substances swell in a comparatively limited number of liquids. In the case of proteins, which have received the greatest attention, conditions are enormously complicated through salt formation and electrolytic and hydrolytic dissociation, and here, as in other problems of colloid chemistry, substantial progress is to be expected only from the study of non-aqueous systems, of which a large number is certainly available. This is also the view expressed by Katz in the monograph already quoted: "Swelling in organic solvents would, perhaps, be more important for an investigation in the service of pure physical chemistry than swelling in water." It is greatly to be hoped that the present discussion may induce competent workers to examine this—equally neglected and promising—field.

* Paper (abridged) contributed to the general discussion on "Colloids" before the Faraday Society and the Physical Society of London, October 25.

* R. O. Rankine, *Phil. Mag. Ap.*, 1906, 447.

† R. Reiger, *Phys. Zeitschr.*, 2, 213, 1901.

## NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

*Iron and Steel.*—Considering the anticipated effect of the stoppage of coal supplies, the staple trades are making very satisfactory progress. Here and there departments have closed down. Some of the steel-making furnaces have been suspended in order to conserve supplies of fuel for those manufacturing sections where a great proportion of workers are employed. But for the most part industry is carrying on at reduced pressure, and a fair tonnage of steel products, machinery and tools is leaving the works for home and foreign consumption. After one week's strike the gross volume of unemployment does not exceed 10,000, which is exceptionally low having regard to the total number of workers normally engaged. Engineering masters state that by running fewer shifts they hope to carry on at the present rate for at least another week, possibly longer. The Order enforcing the reduction of power supply for steel works consumption is making things difficult, and the corporation has agreed to a broad interpretation of the terms of the Order so that the serious dislocation which would result in the lighter trades may be avoided. New business is practically at a standstill. Inquiries for heavy plant and structural steels are still in circulation, but buyers are not inclined to place business without securing fixed rates for delivery, and these cannot be given until the outlook clears. There is a fair volume of work in hand for rolling-stock construction, tramways steel and many kinds of tools. Makers of twist drills report the resumption of foreign competition. Germany has again come into the market and is offering regular deliveries of ample supplies at prices which compare very favourably with the Sheffield quotations, having regard to the condition of the German exchange. Rolling mills are feeling the effect of the slump in motor steel. Depression in the market for steel alloys, following the restriction in the inquiry for tool steels, is more marked than a fortnight ago.

*South Yorkshire Coal Trade.*—Now that stocks are all under control, the market presents very few features worthy of note. There is little likelihood of house coal supplies running short at the moment. Stocks at depots are not yet exhausted, and locally the Sheffield Corporation has a large dump which can be drawn on sparingly to meet the emergency. There are also large stocks at some of the neighbouring collieries in excess of what is required for keeping pumps and fans working. It may be possible to draw on these to assist the steel trade, though whether this will be done without opposition from the miners remains to be seen. A very active demand prevails for blast-furnace coke despite the setting down of several of the largest furnaces in the neighbourhood. Nominal quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

*The Cleveland Iron Trade.*—The pig-iron market continues lifeless, there being hardly any business passing. Nearly all the blast furnaces have now had to either damp down or drop on to slack blast because of the stoppage of coke deliveries, but one or two firms have managed to keep odd furnaces fully going, and in at least one case it has been possible to set a plant fully going that had been dropped on to slack blast. There is no Cleveland foundry pig-iron on the market, but the inferior qualities are offered freely. Makers have rather considerable stocks of forge, mottled and white descriptions for which they do not find a very ready market. For home purposes No. 4 forge, as well as mottled and

white, stood at 225*s.*, and for export forge was 247*s.* 6*d.*, whilst mottled and white were each quoted 230*s.*

*Hematite.*—There is a fair amount of hematite on the market. For home consumption, Nos. 1, 2 and 3 East Coast brands have changed hands at 260*s.*, and sales to Belgium have occurred at 265*s.*, which figure also rules for despatch to France and Italy; whilst for export elsewhere the quotation is 280*s.* Producers are open to make forward contracts at current rates, and indeed some firms are rather pressing sales on such terms for delivery over periods next year.

*Manufactured Iron and Steel.*—Owing to the discontinuance of the coal supply nearly all the works are idle. There are rather considerable stocks of certain descriptions, and from these producers are prepared to sell, but the rates named in several cases are above those of foreign competitors, and it cannot be denied that America and Belgium are making headway in markets which used to draw their supplies chiefly from this district. Principal market quotations stand:—Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel bars, 24*l.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.*; soft steel billets, 23*l.* 10*s.*; hard steel billets, 25*l.* 10*s.*; heavy sections of steel rails, 25*l.*; fish plates, 30*l.*

*Foreign Ore.*—For the time being business in foreign ore is suspended, but resumption of activity is looked for in the near future. Market quotations are based on 50*s.* for best rubio, on the 17*s.* parity freight Bilbao-Middlesbrough.

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*The General Position.*—The second week of the coal strike is now about half way through, and still there is no sign of an agreement being reached by the two sides to the dispute. The latest news gives indications of the outlook being brighter and more favourable, and a proper settlement on an early date would be well received here in the North. Trade in general has fallen away to an enormous extent during the past 10 days, and the numbers unemployed already total many thousands, and if no agreement has been reached by the end of this week these numbers will be considerably augmented. The manufacture of iron and steel has practically ceased, and many of the engineering establishments are gradually getting hung up for want of material, and within a few days further suspensions are anticipated. Export business has been seriously curtailed owing to the difficulty experienced in securing a sufficiency of bunker coal, and many sailings have meantime been cancelled. The outlook is not too bright at the moment, but an early settlement is hoped for.

*Scotch Steel and Iron Trades.*—The past week has almost been a complete blank in the steel and iron trades of the West of Scotland as regards both manufacture and business. Efforts are being made to keep establishments going, in part at any rate, in response to the appeal by the Ministry of Labour, but as reserves of fuel do not amount to any very large tonnage it is doubtful if operations can be carried on for any length of time. Some thousands of workmen in the Lanarkshire district are now idle owing to the stoppage of coal supplies, and the works around Glasgow are all slowing down, and by the end of this week many of them will be suspending most of their employees. There is very little manufactured iron and steel material to dispose of, and the general position is extremely serious. No one has much heart for dealing and neither buyers nor sellers show any inclination to discuss forward lots so long as the position is so obscure. A certain amount of business is going through with foreign makers, and the competition, from Belgian firms alone, has been steadily increasing during the past few months. Their quotations for iron and steel material show quite a considerable reduction on the prices quoted by the local producers, which remain unchanged.

*Scotch Pig-Iron Trade.*—The demand for Scotch pig-iron has fallen away steadily during the past week owing to the closing down, partially or wholly, of consumers' works. In the producers' establishments furnaces are gradually ceasing operations, and damping-down has been general throughout the West of Scotland. Fresh business is not being discussed meantime. Prices have not been altered of late, and show no change.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Coal Trade.*—In view of the continuance of the strike of colliery workers business on the coal markets during the past week has been entirely suspended, as the whole of the coal supplies standing on the docks and railways were requisitioned by the authorities and special permits were required before any could be loaded or removed. At the time of writing it is unofficially announced that the miners' executive and coalowners have accepted the Government proposals for a settlement of the strike, and there is every hope that the miners will be back at work on Monday next. A fortnight's stoppage has, however, resulted in the loss of at least 9,000,000 tons of coal besides having, at any rate temporarily, thrown out of work thousands of men other than those employed at the pits. The loss in output has further resulted in a financial loss to the coal industry alone of some 15,000,000*l.*, equal at least to the net profits of the industry for the nine months ended September. Exports of coal from South Wales to foreign countries in the past week, shipped from stocks on the docks and railway, mined prior to the strike, amounted to 139,000 tons, the smallest for any similar period in the current year, and 139,000 tons less than in the preceding week. Of the total 84,000 tons went to France, 17,000 tons to Italy, 7,000 tons to Spain, 8,000 tons to Portugal, 8,000 tons to British coaling stations and 16,000 tons to other countries. The effects of the strike will be gathered from the fact that out of 245 vessels in the Cardiff, Penarth and Barry docks, coal loading was only proceeding on one vessel to-day, thereby rendering idle about 1,500 coal trimmers. These men in the past week were paid about 4*l.* per man out of the wages pool, half of which represented back money, as compared with an average of 6*l.* per week before the strike. It is also estimated that about 1,500 sailors and firemen are unemployed, while last week only 67 men were signed on at Cardiff, as compared with 137 in the last week in September. All the patent fuel works in South Wales, with the exception of two small factories making ovoids for household use, have been thrown idle, rendering about 3,000 men idle and resulting in a loss of some 50,000 tons of fuel a week, most of which is sent abroad. Casual workers at the dry docks have also been affected, for it is stated that out of 7,000 at Cardiff, Penarth and Barry quite 5,500 are out of work at present.

*The Iron and Steel Trades.*—This section is also suffering from the coal strike, and it is believed that it will be some time after a settlement before something like normal conditions are restored. The steel bar mills are idle, but so far most of the tin-plate works have been able to keep going. Deliveries have been thrown into arrear, and there is a fair speculative inquiry on the basis of 40*s.* a box for both prompt and forward delivery, but makers are holding for 42*s.* to 43*s.* In galvanised sheets prices are lower at 37*l.* to 38*l.*, for 24-gauge corrugateds in bundles.

TIME-KEEPING WITH A CHRONOGRAPH WATCH.—Since the accurate measurement of physical quantities forms an important item in the work of an engineer, our readers will doubtless be interested to know what degree of precision can be obtained in the measurement of time by a high-class watch in everyday use. For this reason we propose to give some particulars of the time-keeping properties of a compensated chronograph watch, with lever escapement, made in 1914 by Messrs. S. Smith and Son, Limited, 6, Grand Hotel Buildings, Trafalgar-square, London, W.C.2, but not delivered to the purchaser until October, 1919. For the last six months the customer has checked this watch by means of the wireless time signals sent out from the Eiffel Tower, and, over this period, the extreme variation in the rate has been found to be from − 0·8 sec. a day in May to + 1·2 secs. a day in June and July. During September and for the early part of this month, the mean rate was constant at 0·1 sec. a day, and the maximum deviation of any individual reading from this straight line rate was 1·3 secs. The mean rate, it may be added, represents an error of less than ·00012 per cent. These results are remarkably good considering the fact that the watch was in ordinary use during the whole period over which it was checked, having been carried in the pocket during the daytime and placed on a dressing-table each night. This particular watch was awarded an "Especially Good" certificate, with 82·5 marks, at the National Physical Laboratory in 1914.

THE HEATH UNIT HOLLOW BRICK.—Our attention has been drawn to a form of hollow burnt clay brick which is being largely adopted in the United States with the object of reducing building costs. This brick is made on the unit system, and four types of unit provide all the necessary shapes for bonding, corners, joints, lintels, piers and pilasters, &c. The standard unit for plain construction is a hollow block, 8 in. by 5½ in. by 11½ in., halves being 5½ in. long. The brick is pierced by three rectangular voids, of which the two outer are 2½ in. by 4 in., while the central one is only ½ in. wide by 4 in. deep. This leaves walls ½ in. thick, and two webs ½ in. thick near the centre separated by only ½ in. The exterior of the brick can be grooved on all sides so as to give a bond for plaster, &c., but ordinarily two faces are plain. The central web naturally results in a very strong brick, which will stand a breaking test of 90 (short) tons per square foot. Wasters in manufacture are said to run out at below 2 per cent. either due to warping in burning or breakage. These bricks have all the advantages of other hollow bricks in the saving of raw material, of fuel for burning, freight charges in transport, load on foundations, &c. The voids amount to about 40 per cent. of the total volume. The three interior voids provide more efficient insulation than is secured in many patterns of hollow wall construction now being adopted. The units can be utilised in all the usual bonds, while an interlocking bond may be adopted for use with plain brick lining. The second unit is a brick 3½ in. by 5½ in. by 11½ in., with a single void. Two such units side by side set over the standard unit bring the walls over the webs of the latter, leaving a ½ in. space between. The corner and pilaster units are respectively 8 in. by 2½ in. by 5½ in. and 8 in. by 3½ in. by 5½ in., and contain less voids. All the units can be made with three dies which can be readily adapted to existing machines. We are informed that the comparative cost of building in the United States has been found to work out at 39·57 for the unit construction compared with 50·67 for brick construction, these figures including first cost, handling, laying, mortar, &c. Of course, these figures would be modified here somewhat. The International Heath Unit Tile, Inc., of Tacoma, Washington, is arranging for the manufacture of this brick in this country, Mr. E. J. Felt, Hyde Park Hotel, London, representing the firm here at the present time.

## NOTICES OF MEETINGS.

THE SOCIETY OF ENGINEERS.—Monday, November 1, in the Apartments of the Geological Society, Burlington House, W. The proceedings will open at 5 p.m. with a social gathering of members and visitors, after which a paper will be read at 5.30 p.m. on "Engineering Accounts," by Mr. H. McFarland Davis, Assoc.S.E., Assoc. Inst. Chd. Accts.

THE BRADFORD ENGINEERING SOCIETY.—Monday, November 1, at 7.30 p.m., Meeting in the Engineering Lecture Room of the Bradford Technical College. Mr. L. Roberts, of Bradford, on "Types, Applications and Advantages of Synchronous Motors," with lantern illustrations.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 2, at 5.30 p.m., Address by Mr. John Alexander Brodie, M.Eng., the president, and presentation of medals awarded by the council.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 3, at 8 p.m., the Forty-seventh Session will commence at the Royal Institution, Colquitt-street, Liverpool, when the president, Mr. J. R. Davidson, C.M.G., M.Sc.(Vict.), M.Inst.C.E., will deliver his Inaugural Address.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, November 4, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. A paper entitled "The Human Machine in Relation to Flying," will be read by Wing Commander M. Flack. The chair will be taken by Sir Humphrey Rolleston, K.C.B.

THE NEWCOMEN SOCIETY FOR THE STUDY OF THE HISTORY OF ENGINEERING AND TECHNOLOGY.—Friday, November 5, at 5.30 p.m., at the Patent Office Library, Southampton Buildings, E.C. Paper by Mr. E. W. Hulme, M.A., Member: "Introduction to the Literature of Historical Engineering."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 5, at 8 p.m., at the Caxton Hall, lecturette, "Some Further Locomotive History," by Mr. Ernest Cooper, Member.

THE ROYAL AERONAUTICAL SOCIETY.—The annual dinner of the society will take place in the Connaught Rooms at 7.30 p.m. on Wednesday, November 17. The Right Hon. Lord Weir of Eastwood, President of the Society, will take the chair. It has been decided that, in corresponding with countries served by an air mail, the society will, in future, forward all its letters by that means. If all members of the society would follow this example it is thought that practical assistance would be given to the development of civil aviation.

INSTITUTION OF NAVAL ARCHITECTS: SCHOLARSHIPS.—The following scholarships on naval architecture and marine engineering have been awarded by the Council of the Institution of Naval Architects, viz.:—*Naval Architecture;* Vickers' scholarship (150*l.* per annum), to Mr. E. Smith, of Messrs. Denny Brothers, Dumbarton; J. S. White scholarship (100*l.* per annum), to Mr. C. A. Oakley, of Messrs. John Brown and Co., Clydebank; Hawthorn Leslie scholarship (150*l.* per annum), to Mr. E. F. Craggs, of Messrs. Hawthorn, Leslie and Co., Hebburn-on-Tyne. Denny scholarship (75*l.* per annum), to Mr. J. A. Bennett, of Dumbarton. *Marine Engineering;* R. L. Scott scholarship (150*l.* per annum), to Mr. A. Cameron, of the Fairfield Shipbuilding and Engineering Company, Govan. Denny scholarship (75*l.* per annum), to Mr. F. R. Topping of Dumbarton. Sir William White post-graduate research scholarship in naval architecture (150*l.* per annum), to Mr. A. Fletcher, B.Sc., of Messrs. Swan, Hunter and Wigham Richardson, on the nomination of Armstrong College, Newcastle-on-Tyne.

MESSRS. THORNYCROFT AND SPANISH SHIPBUILDING.—When Messrs. John I. Thornycroft and Co., Limited, took over the management and control of the Astilleros del Mediterraneo, Barcelona, the ss. Berga was under construction in that shipyard, and Messrs. Thornycroft took charge of the work and expedited its completion. The Berga was launched recently at the shipyard in question. She is a merchant vessel of 1,625 tons displacement, with a carrying capacity of 1,020 tons; she has been built for a Spanish firm under the inspection of Lloyd's Register branch of the Spanish Shipping Company. The Berga measures 192 ft. between perpendiculars, with a maximum beam of 29 ft. and a draught of 14 ft. She will be driven by triple expansion engines of 12 in., 30 in. and 32 in. respectively, developing 500 i.h.p., steam being generated in two boilers working at a pressure of 180 lb. per square inch. For working the ship's auxiliary gear, three small steam engines and a motor engine are installed, also a wireless apparatus and electric lighting. The Berga's cargo holds carry 518 cub. m. and 882 cub. m. respectively, her bunkers have a capacity of 230 tons, and her two ballast bunkers carry, one 77 tons and the other 99 tons. A twin vessel to the Berga is already approaching completion, while two larger ships, to carry 2,500 tons, are under construction in the same shipyard, and are well advanced. It is hoped to commence work very shortly on two 2,700-ton vessels, also on several smaller boats for which orders have been placed. The Barcelona shipyard is splendidly equipped with modern appliances, including three large cranes capable of dealing with the heaviest lifts likely to be handled, and under Messrs. Thornycroft's control promises to develop into a very active shipbuilding centre.

# 60-TON ELECTRIC OVERHEAD TRAVELLING FORGE CRANE.

CONSTRUCTED BY SIR WILLIAM ARROL AND CO., LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page 572.*)

Fig. 6. Crane in Operation at Dennystown, Forge, Dumbarton.

# 40-B.H.P. MARINE TWO-CYCLE HOT-BULB OIL ENGINE.

CONSTRUCTED BY MESSRS. NORRIS, HENTY AND GARDNERS, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page 569.*)

Fig. 2.

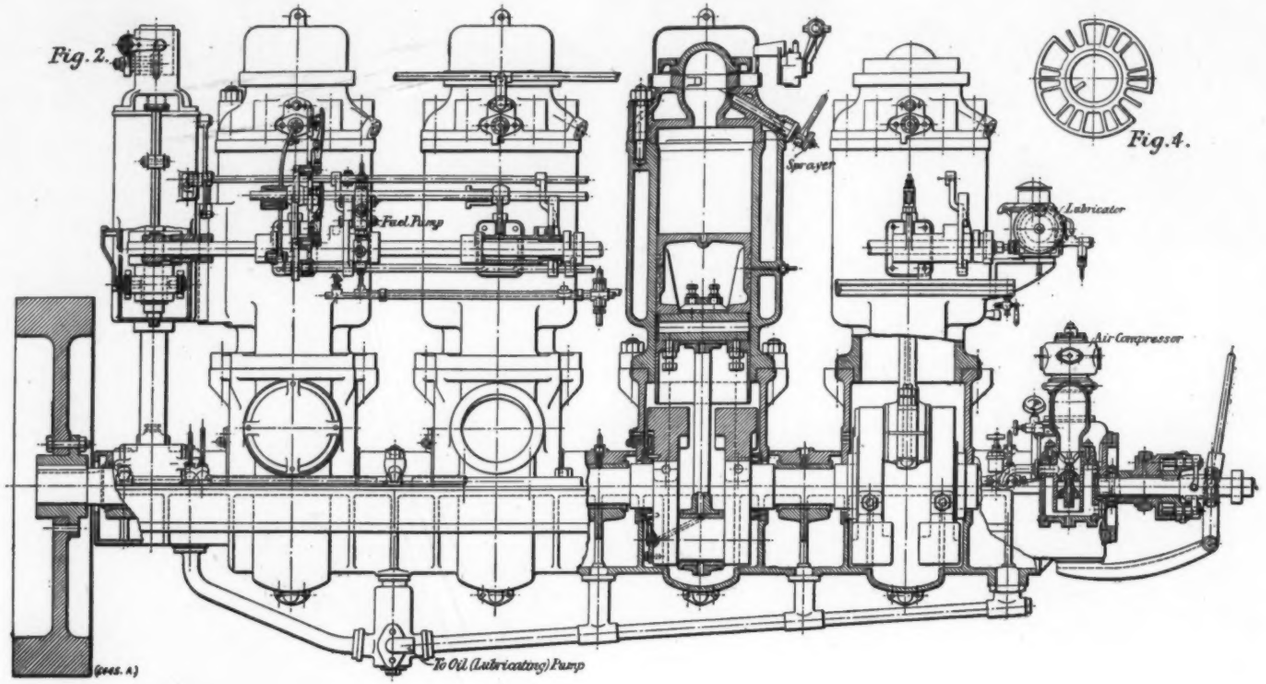



Fig. 4.



Fig. 3.

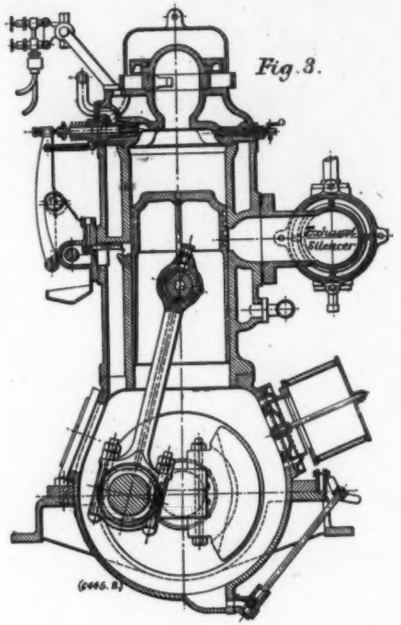



Fig. 5. FUEL PUMP & MOTION WORK

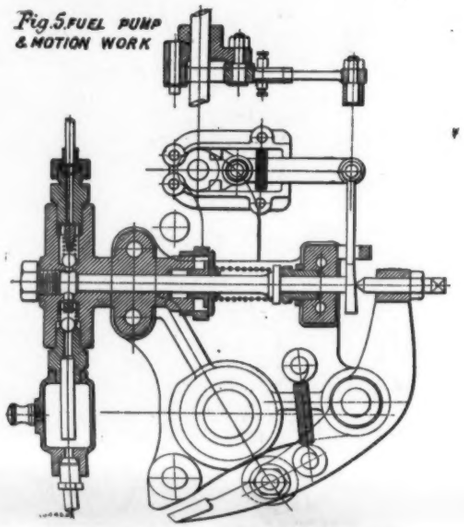


Fig. 6.

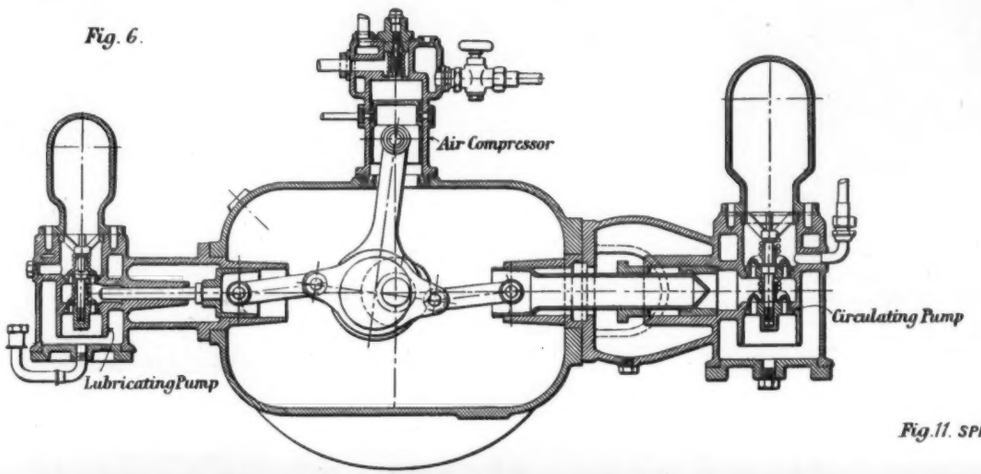



Fig. 8. AIR COMPRESSOR.

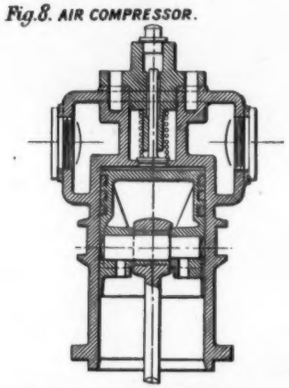


Fig. 11. SPRAYER.

Fig. 7. CIRCULATION & LUBRICATION PUMPS.

Fig. 13. SECTION D.D.

Fig. 12. REVERSING GEAR & GOVERNOR

Fig. 7. CIRCULATION & LUBRICATION PUMPS.

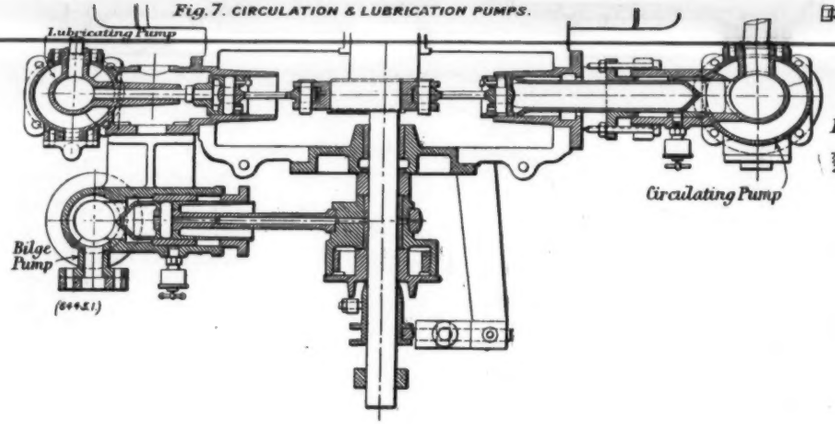



Fig. 9. WATER CIRCULATING PUMP VALVES.

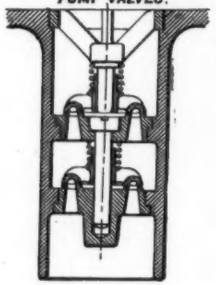


Fig. 10. LUBRICATION PUMP VALVES.

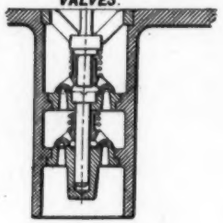


Fig. 13. SECTION D.D.



Fig. 12. REVERSING GEAR & GOVERNOR

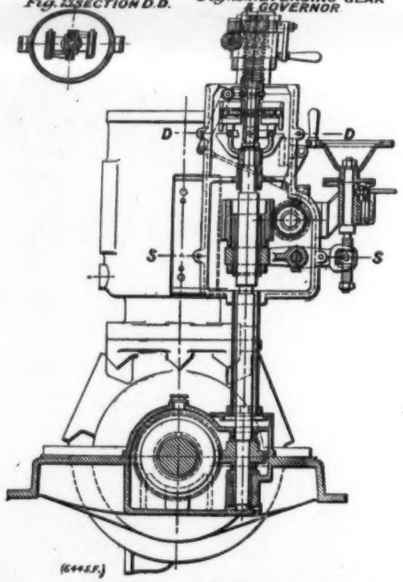



Fig. 14. SECTION S.S.

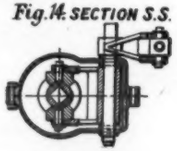


Fig. 15. EXHAUST SILENCER.

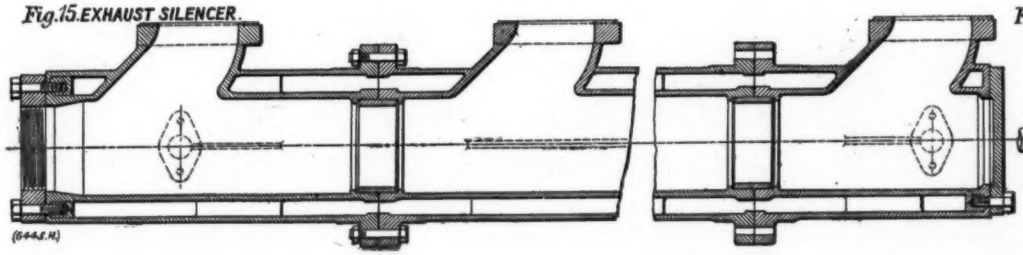



Fig. 16.

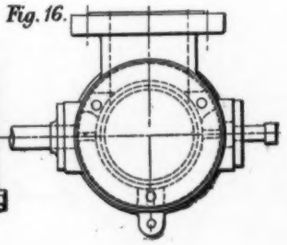
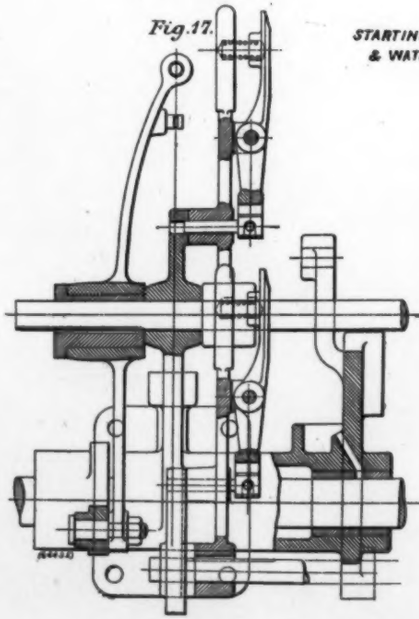


Fig. 17.



STARTING & STOPPING GEAR & WATER DRIP CONNECTION

Fig. 18.

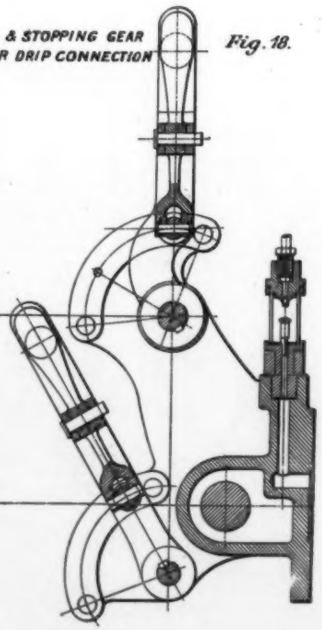


Fig. 19. BILGE PUMP.

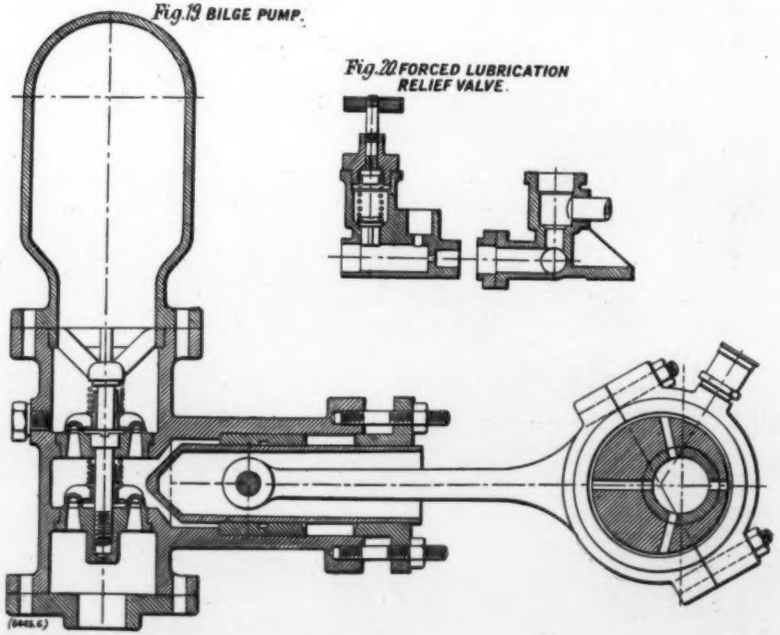



Fig. 20. FORCED LUBRICATION RELIEF VALVE.

## AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm Dawson and Sons, Manning Chambers.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co., Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino. And any post office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Haywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long Street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements, J. S. Allan, 30, Church-street, New York.

## ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

**Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.**

## SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

| | |
|---|---|
| For the United Kingdom | £3 5 0 |
| For Canada— | |
| Thin paper copies | £2 18 6 |
| Thick ,, ,, | £3 3 0 |
| For all other places abroad— | |
| Thin paper copies | £3 3 0 |
| Thick ,, ,, | £3 7 6 |

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

**Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.**

TELEGRAPHIC ADDRESS: "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3883 and 8598 GERRARD.


## CONTENTS.


| | Page | | Page |
|---|---|---|---|
| The Production of Sound under Water by the Condensation of Steam (*Illus.*) | 561 | Notes from the North | 575 |
| Recent Developments of Electrically - Heated "Revel" Boilers in Switzerland (*Illus.*) | 563 | Notes from the South-West | 575 |
| The Institution of Mechanical Engineers | 565 | Notices of Meetings | 575 |
| Literature | 566 | Mechanical Engineers in War | 577 |
| Books Received | 568 | The Present Position of Industry | 578 |
| 40-B.H.P. Marine Two-Cycle Hot-Bulb Oil Engine (*Illus.*) | 569 | The Military Lorry | 578 |
| Industrial Notes | 570 | Notes | 579 |
| The Late Mr. William Melville, C.B.E. | 571 | Colloids | 580 |
| Notes on New Books | 571 | Steel Forged Back Axle for Motor Vehicles | 582 |
| 60-Ton Electric Overhead Travelling Forge Crane (*Illus.*) | 572 | "Time and Lime" | 582 |
| Nitrocellulose | 572 | The Institution of Mechanical Engineers—President's Address | 583 |
| The Properties of Elastic Gels | 574 | 2-10-0-Type Locomotive: Pennsylvania Railroad (*Illus.*) | 587 |
| Notes from South Yorkshire | 574 | A Short Survey of the Physics and Chemistry of Colloids | 587 |
| Notes from Cleveland and the Northern Counties | 574 | The Present Position of the Marine Diesel Engine (*Illus.*) | 589 |
| | | Catalogues | 592 |


*With a Two-Page Plate of a* 40-B.H.P. *MARINE TWO-CYCLE HOT-BULB OIL ENGINE.*

**NOTICE.**

**A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.**

**NOTICE TO NON-SUBSCRIBERS.**

**In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.**

**NOTICES OF MEETINGS.**

**Notices of Meetings to take place during the present and next week will be found on page 575.**


# ENGINEERING.

*FRIDAY, OCTOBER* 29, 1920.


## MECHANICAL ENGINEERS IN WAR.

It is frequently true that history written too near the event, although a correct record of certain facts, may be wanting in all sense of proportion. Such has been the case with regard to the war. It came to be a commonplace that it was an engineers' war, and various parties have taken credit to themselves that the particular type of engineer they represent was the main factor in the successful issue. The civil engineer with his roads and bridges, miles of railways and water pipes, and the electrician with his signals have already had their say, but though we are not in any sense wishing to detract from the value of their faithful work, we hold that as time passes, and we get to view the whole in truer perspective, the claim of the mechanical engineer as really the critical factor in the late war will generally come to be admitted. The chronicle of his work in no sense suffers from the fact that it has been somewhat delayed. His all-pervading activities in the main and decisive stages are emphasised thereby. Only when the pre-eminent necessity of developing his services to the utmost was acknowledged, and he came into his own, did we make real headway in hastening the actions of just two years ago, which culminated in so glorious a close. Great and marvellous were his works!

We are still waiting for a comprehensive summary of the mechanical engineer's contributions to the war. Captain R. H. Sankey, C.B., in his presidential address, delivered on Friday last before the Institution of Mechanical Engineers,* has given us an outline of his achievements in some fields, but has avowedly only touched upon the fringe of the subject. The President of the Institution, for instance, has dealt with the work of only one munitions committee out of nine and, further, has not included the work of the regular armament firms and national munitions factories. Again, the organisation in France has alone been summarised for the very good and sufficient reasons which Captain Sankey gives. But the engineer was no less prominent in the successes in Africa, Palestine, Mesopotamia and other countries, than he was in France, and often with more credit. In France, with England and her factories just at the back door, all reasonable facilities were comparatively speaking promptly forthcoming. But in the areas far afield supplies of plant and stores were bitterly hard to come by, and when campaigns led, as many did, to rather unexpected developments, the engineers needed almost the skill of wizards to meet the requirements of G.H.Q. Naturally, the scale of operations gives the Western Front first place, but in actual accomplishments it is doubtful if other areas have not at least as good engineering records. We hope that our technical institutions may some day find it possible to spare a few pages of their proceedings to such chronicles, as well as to those of France and England.

As the mechanical engineer made good to such a pronounced degree when given his opportunity, we need not dwell on that lamentable stage of the conflict when he was either encouraged to enlist in the ranks if young enough, or if too old for that was permitted to do unskilled labourers' work in ordnance factories at the week-ends. Such indignities are not likely again to be offered to the profession. But it would be interesting to know whether, in all the military re-organisation which is afoot, the mechanical engineer as such is going to be given a place. There are numbers of officers who have served with credit—many with distinction and honour—with temporary commissions. How do they stand? Most of them have very little idea whether they are liable to further service in the event of emergency, or whether they will be able to fall into some organisation which, if their services are required, will ensure their use in a suitable manner, without the series of rebuffs encountered on the last occasion.

Captain Sankey, in his address, touches upon the subject of a Corps of Mechanical Engineers, and a register of members at the Institution for use in connection therewith. We reproach ourselves as a nation with lack of foresight with regard to 1914. Is all the organisation so elaborately built up between 1916 and 1919 to drop away as we get older? It may be a short time, or it may be long, before we again have to arm the nation. Possibly it will then be past the power of those who have helped this time to repeat their services. Is anything to be done to replace them so that we shall not again incur the reproach of unpreparedness? The Territorial Force is being re-shaped, but though it includes engineer troops it does not seem to furnish the skeleton organisation necessary to large and rapid expansion. The Special Reserve of Officers, R.E., of pre-war days, does not meet the case. At present the average mechanical engineering apprentice or young engineer as likely as not, if interested in the Territorials, will join the infantry or artillery branches. We would like to see some scheme afoot for roping in these young men for the commissioned ranks, in units in which they would be employed in their own professional work or work closely akin thereto. They would thus form a reserve of mechanical officers to staff units as the expansion of the forces required. Their work when mobilised should form a continuation of their civilian work. This would enable a lad who had served part of his apprenticeship to count his military service as part of his training. At present an apprentice obtains, say, an infantry commission. The Army has to train him afresh from the elements of the work, and when he returns to his civilian vocation he is like a fish out of water and has to complete his apprenticeship under very unfavourable conditions of age and so on.

Might it not be possible to get these lads interested in military service, and attach them as cadets or supernumerary officers to Territorial units, R.E. or otherwise, for training purposes in peace time, so that they might learn much that every soldier should know about orderly-room routine, internal economy, the use of arms, &c., and so, when their services are needed by their country, come prepared with a foundation at least, if no more, of the knowledge of the military side, backed with their professional experience in civilian life. It should be feasible to dispose in some such way of practically every graduate entering the Institution of Mechanical Engineers. The fit would be on one list, and the others marked for home work in connection with munitions.

Captain Sankey asked in his address whether the gauges made during the last war were being properly preserved for the next. No less important in our opinion is this question of a framework for an officer organisation composed of the young engineers on whom the work in the field must next time devolve. A good deal of this work is outside the regular R.E. scope, even of the E. & M. Section, and does not actually require the generally recognised R.E. training. For many of the duties to be performed a man is well equipped with his professional knowledge and a sound ground-

* See abstract, page 583 *et seq.*

ing in military subjects, such as discipline, organisation, &c. With Captain Sankey we would like to see instituted a Corps of Mechanical Engineers, and with the Institution aiding in its development and organisation, all the younger members of the profession might be brought within its scope in some skeleton or nucleus scheme such as we have suggested, for work either abroad or at home, in time of stress. The work of the mechanical engineer in the last war makes a brave record. May it be possible by timely organisation to improve upon it in the next.

## THE PRESENT POSITION OF INDUSTRY.

During the months immediately following the armistice it was commonly said that the country would experience a run of prosperity which might extend for as long as five years, but that sooner or later the war would be followed by a period of industrial depression. This depression was foretold not as one of the troughs of the ordinary cycle of good and bad trade, but as something unusually acute. The destruction caused by great wars in the past has been followed by phenomena of this kind and the prophesy was generally accepted. Almost two years have now passed since the armistice, and it is a matter of somewhat painful interest to speculate whether we are, or are not, approaching the trough which is following our wave of prosperity. Too much has probably been made of present statistics of unemployment, but it is at least clear that many branches of trade are less busy than they were six months ago. The coal strike has, of course, introduced new factors into the problem, but this apart, there are apparently signs that markets are weakening.

The idea of an era of bad trade following sooner or later on the heels of the war is probably sound, but it is not too certain that the wave of prosperity which by hypothesis should precede the lean period has had any actual existence. The mere spending of money is no evidence of solvency, and although trade has been brisk and manufacturers have had more orders than they have been able to fill it is doubtful if matters have at any time been on a sound basis. Clearly this country, Europe, and many other parts of the world, have wanted supplies of all kinds to make up the wastage of the war and to fill the gap caused by the cutting-off of normal channels of trade for several years, but these demands are still far from satisfied, and if our apparent prosperity was a real one, based on the effective meeting of these demands, there is no very evident reason why it should now decline. The industrial activity of this country during the last year or so has certainly been partly due to genuine demand arising as an aftermath of the war, but it has also to a large extent been due to reckless spending in this country, also certainly an aftermath of the war, but one due rather to nervous reaction than to a genuine demand for material to meet a shortage.

The problem of to-day in our industrial world is not how can we prolong the feverish period in which industry has been living, but how can we get industry down to a sound basis on which there shall be fair correspondence between prices and values, wages and services. This cannot be done by any mere insistence on the necessity for more production. The necessity is glaring, but no great progress is likely to be made by a mere repetition of a cry about output and the working man. The problem of the future of industry is an exceedingly complex one, touching every side of our national life, and it is not to be expected that any one can put forward a formal scheme which will end all our troubles. This is not to say, however, that more hope may not lie in constructive proposals than in barren attacks on the mental attitude of the working classes.

Although we are inclined to criticise much of the infructuose talk about production which has been in evidence, we are in no way inclined to minimise the importance of such increased production. High prices, unfavourable exchanges, heavy debt, are all best met by increasing our output both of manufactured articles and food-stuffs, and the problem before us is the production of practicable schemes which are likely to lead to this end. It is probable that ultimately the hard school of experience would teach both our working people and their employers that a better output per unit of labour and unit of capital is essential. The alternative is a general lowering in the standard of living which would not be accepted indifferently. It is permissible to hope, however, that much improvement may be achieved by a fuller general appreciation of prevailing economic conditions and by the setting in operation of definite movements calculated to increase the countries' output, while not running counter to the modern aspirations of labour. These latter are an important factor in the problem, and one which cannot be ignored with profit.

As an actual definite scheme for improving present conditions much interest attaches to the proposals put forward by Lord Weir in his address to the Glasgow Chamber of Commerce last week. Lord Weir has more than once spoken, or written, helpfully on the subject of the present position of industry and his Glasgow proposals may, we think, be taken as a crystallisation and formal statement of his ideas. His proposals briefly were, the stabilisation of wages for twelve months; the assumption of responsibility for unemployment relief by industry as a whole; the acceptance of payment by results by the trade unions; the recognition of the State of the principle of freedom of employment; and the temporary increase of working hours. There were other proposals in connection with taxation and national expenditure, but we will not attempt to examine them now. What one may term the labour clauses of his proposal are sufficient to occupy us at the moment.

It is quite evident that this programme bristles with difficulties. The greatest of these certainly turns on the freedom of employment, but others such as the length of the working day and payment by results are not likely to be accepted by organised labour without a very substantial offset. This is, of course, furnished by the unemployment proposals which really meet much of labour's present opposition to dilution, overtime and other methods of increasing output. We hope, however, and we imagine Lord Weir hopes, that the better brains in the labour movement may be persuaded to examine the proposals on their merits and from the point of view of the ultimate good of the whole country. No profit can, however, come from agreements with the better brains of labour which are not likely to be accepted by its ranks, and it will be well briefly to examine the proposals with this idea in mind.

The first clause in the scheme—the temporary stabilisation of wages—might at first sight appear impossible of attainment in view of the fact that so large a proportion of our strikes and labour troubles turn on questions of wages advances. There would naturally be difficulties, but we are optimistic enough to think that such a stabilisation might be brought about. There are but few of our trade union leaders who have not a fair idea of the industrial difficulties of the country, and we think they might be persuaded strongly to recommend a temporary stabilisation of this kind. The weakness we see in this particular proposal is not that it could not be carried, but that the period proposed is too short for any proper advantage to be taken of it by our manufacturers. If one begins to suggest periods of two years, or longer, however, a quite new order of difficulty will be introduced into the problem, and we may leave the twelve months as a very desirable compromise.

When we turn to the question of the acceptance of payment by results by the unions as a whole we are again obviously at once confronted with difficulties. In this case, however, we think the opposition would come more from certain unions officially than from the individual workpeople. This should make the matter more easy to deal with. Various systems of payment by results are, of course, in operation in many trades, and in general are certainly favoured by the people who work under them. In other trades the system is forbidden, but we know of more than one case in which such a system is being worked to in certain shops with the full concurrence, and even at the desire, of the workpeople in defiance of union rules. A general acceptance of payment by results is not going to be granted off-hand, but the bringing about of such an acceptance is a sufficient possibility to make the matter well worth bringing forward in a definite way. It certainly does not constitute the greatest difficulty of Lord Weir's scheme.

It is when we come to an increase in working hours and the recognition of the principle of the freedom of employment that our real difficulties begin. The former of these proposals would certainly arouse great opposition, but as we regard it as the least important clause in Lord Weir's scheme we need not discuss it at length. If the other clauses were accepted the longer working day might be allowed to go. The recognition of the principle of the freedom of employment is altogether a different matter, however. It is really the basis of the whole scheme. The expression in itself looks harmless enough, but when trade unionists realise what it means we are afraid the opposition will be of a very drastic character. Freedom of employment means the relaxation of trade union rules and the employment of unskilled and semi-skilled labour in any trade and on any job with which they are able to deal. There is no need to enlarge on the trade union attitude to this suggestion.

It requires no comment on our part to enable any one to realise the extraordinary gain in output and the increase in strength of our industrial position which would follow these suggestions of Lord Weir's could they by any means be brought to be accepted. Naturally, however, organised labour would require very substantial proposals as an offset before it could be brought even to discuss them. These proposals are represented in Lord Weir's scheme by the assumption of responsibility for unemployment relief by industry as a whole. This proposal really meets the position which labour has usually taken up in reference to dilution, overtime, &c. Opposition to increase of output by means of this kind has usually been based on arguments to the effect that in the long run such methods must lead to an increase of unemployment. The present position in reference to bricklaying is a striking instance of this. Were this the only basis of labour opposition, a satisfactory and practical scheme of unemployment relief would go far to meet it. It is to be feared, however, that some of the opposition to dilution is really based on what is really a caste feeling. Skilled unions have during years of work and strife built up a position for their members which in certain respects is exclusive, and their opposition to dilution is based to some extent on the maintenance of that exclusiveness.

We do not know that Lord Weir put forward any proposals for the formal consideration of his scheme by labour, manufacturers and the Government, but the mere publication of his ideas should do good. It is greatly to be desired that his proposals should be considered in a definite way, but in view of their sweeping character we have little hope that they will be accepted nationally. The advantage of the scheme as an overall one is that the unemployment problem would be tackled and settled on a national basis, but in view of the very serious labour opposition which would be aroused by some of the other clauses, we think a proceeding by individual trades would be more likely to lead to success. It is not likely in any event that the proposals would be accepted as they stand, but a definite and generous unemployment scheme put forward by an important industry might result in important output concessions being obtained from labour. The weakness of this is that the prosperity of the country is a common matter at bottom, and no single trade could reap full benefit even from the complete scheme if other trades stood out. In a matter involving such difficulties, however, it is not unpolitic to be satisfied with small advance at first in the hope that one step gained may lead in time to the next.

## THE MILITARY LORRY.

Before the recent war no one imagined that the day would come when our Army mechanical transport service would expand to the huge dimensions it reached in 1918, and the chief concern was the provision of about 1,700 vehicles for the Expeditionary Force. This, as we all know, was practically

secured by the subsidy scheme in force before the war, though a small balance of vehicles had to be impressed. Now that we have had time to look round since the conclusion of the armistice and take stock of the position, it does not appear that the future will be easier than the past for the solution of the problem of the military lorry, for several well-defined reasons.

In the first place, civilised countries are, as rapidly as the times permit, raising the standards of their roads. Foundations are being strengthened and surfaces improved, grades are being cut down and generally everything is being considered which will enable higher loads to be carried on our roads at higher speeds.

On the other hand, the late war has taught us that much if not most of our transport in war areas has to be conducted over abominably bad roads, and not infrequently over country with no roads at all, ranging through all possible physical characteristics from desert tracts of earth or sand to thick jungle, rugged hill country or the chill arctic zones. It may well be asked whether a vehicle which will suit the civilian user can so be contrived as to suit equally the requirements of the War Office when its sphere of action is as wide as that just indicated. On the face of it, it would seem that the civilian vehicle is likely to develop upon rather unsuitable lines.

There are roughly three classes of work for the lorry—at home on good roads, in the Colonies on bad roads, and in war with possibly no roads. A good deal was heard at the Imperial Motor Transport Conference on the 20th and 21st inst., held at Olympia, on this difference. The most interesting meeting at this conference was probably that on the Thursday, when Major-General Sir E. E. Carter, K.C.M.G., took the chair, and the subject of the adequate supply of motor vehicles suitable for military purposes was introduced by Major Snowden-Smith. Major Snowden-Smith prefaced his remarks with a review of the subsidy scheme in force before the war, and gave some forecast of the new scheme about to be introduced. The latter would at first apply only to the 3-ton machine. Subsidised vehicles would be subject to examination, and the price would be worked out, deducting 15 per cent. p.a. for depreciation from the owner's cost, and adding to the figure thus obtained 25 per cent. This scheme would act as a stop-gap until the new War Department specification is brought out. As far as we can discover, the scheme is to be applicable to this country; but it is clear that in many respects a more suitable machine will be found in the hands of the colonial civilian than in those of the home user, and a subsidy specification working in this direction would probably in the end produce better results. Yet even here we find a great divergence of opinion. Many speakers at the conference dwelt on the imperative need for a light car where roads could hardly be said to exist. Although uneconomical there is no doubt that the light Ford cars did a lot of useful work in the recent campaigns in roadless countries. Their consumption, which was about 8 miles to the gallon, was, of course, often against them, as for instance in the Dunster Force expedition from Baghdad to the Caspian, when each car took about 5 cwt. of petrol on the journey, all of which had to be carried, thus limiting their useful load considerably.

Several speakers referred to the 1-ton lorry with a trailer as a possible combination of service alike to the military and to the civilian in such countries as Central Africa and other colonies. But in the more advanced countries, of course, we are getting further ahead than that, and it is difficult to see how a practical scheme can successfully cover the many fields and produce from any one a reasonably large number of suitable vehicles. All, naturally, ultimately turns on the number of vehicles wanted, and this alone will require much consideration. We all want to be prepared for the next war, but who knows where it will take place and whether we should be able to avail ourselves of vehicles subsidised in the Colonies? The ideal certainly would be to have standardised types with standardised parts, covering all possible conditions of service, but then there is no knowing whether some turn of political events might require us to concentrate in Europe or in the trackless countries of Asia. The lorry of the home user, built to get the most out of good roads, under police regulations, does not promise to meet the case exactly. The colonial machine, if such ultimately develops, would seem more likely to do so, though there will always be areas where the light car in war will do useful though perhaps somewhat costly work. Cost, however, in war is not a matter of petrol or money if strategic superiority is securable; we would have fared badly indeed in the recent conflict if we had rated everything in money.

Apparently the new War Department specification will be delayed until it has been possible to collate all the information which is derivable from the use of lorries in the field in the recent years. We understand that it has not yet been possible to complete the study of these valuable data, and the mass of information available must be enormous and the lessons to be deduced therefrom must indeed be numerous. It is satisfactory to know that when it is classified the authorities will place it before the manufacturers of this country, for the benefit of designers. It is only by a knowledge of failures that improvement in many respects can be made, and never before has there been such an opportunity for gathering this together as in the recent testing years. An idea of some of the lessons may be gathered from articles which have appeared in these columns, but the data available to the War Office is still far wider than that on which these have been based, covering as the information does all the war areas.

## NOTES.

### International Agreement as to War-Time Patents.

An international arrangement concerning the preservation or re-establishment of rights of industrial property (patents, designs and trade marks) affected by the war, was signed at Berne, on June 30, 1920, and has since been signed and ratified by Great Britain, France, Germany, Poland, Sweden, Switzerland and Tunis. Czecho Slovakia, the Netherlands and Portugal have signed the arrangement, but have not yet deposited their ratifications. The arrangement provides for the extensions of time for filing applications under the International Convention for the protection of industrial property, and also for extensions of time for accomplishing any act, fulfilling any formality, paying any fees and generally satisfying any obligation prescribed by the laws or the regulations of the signatory States. Under this arrangement it will be possible, until January 10, 1921, so far as this country is concerned, to file applications for patents under the International Convention or to revive any lapsed patents by paying up the overdue taxes, if the Convention period had not expired on August 4, 1914, or the patent had not lapsed before that date and the applicant or patentee is a subject of one of the signatory States. The new arrangement really gives the patentees the right to apply for a patent or pay an overdue tax, in cases in which they have had previously to depend on the making out of a case that they had been unable to take the necessary action owing to circumstances arising out of the war.

### Technical Societies as Educational Institutions.

Few engineers will be found to traverse the contention that technical institutions, rightly conducted and vigorously supported, have a very considerable educational value. This idea is elaborated in his recent presidential address before the North-East Coast Institution of Engineers and Shipbuilders, by Mr. A. E. Doxford, and is carried to the interesting conclusion that as a consequence such institutions should be endowed. The engineer's education we all know is never completed. The school and college training, and the apprenticeship are only the groundwork or foundation of the structure we are able subsequently to raise, and such education is generally recognised as mainly enabling us to make a good start on the more serious work of life. With the general increase of knowledge it is necessary for more to be acquired in the preliminary stage, but only as a man continues his education subsequently will he win to a good position in the profession. Mr. Doxford's idea is that where the college ends the technical institution should step in and carry on. These bodies are supposed to be composed of engineers of like interests, anxious for the advancement of their branch of the science to be facilitated by the dissemination of knowledge. Of course, institutions do not always work out quite this way in practice, but it is the nominal ideal of all. Most people join an institution for what they can get out of it, which in other words means they hope to learn something which will be useful to them. Of course this service should be reciprocal, and if they get something, something should be given in return, so that by general reciprocity the benefit to all members may be a maximum. Most of the societies, though one does not realise it, perhaps, are of very practical value. They popularise improvements and aid in the search for economies in a way which influences ultimately a very large section of the profession. If the germ of some idea of an alteration were traced back in the mind, it would frequently be found to have had birth in some remark in a paper, or in words dropped by a speaker in a discussion. For these reasons Mr. Doxford claims that more should be done by successful engineering firms in the way of supporting these societies, which broaden the knowledge of those men on whose efforts their success is maintained. He pleaded for the endowment of societies by such firms as the most rational direction in which those bodies might look for help. With the ever-increasing personal expenses there is little hope of securing much increased assistance from the members themselves, save in exceptional cases. State aid is also probably out of the question in these days when the national expenditure is so enormous, and efforts are supposed to be made to curtail it where possible. There remain the firms staffed by members of the societies, whose growing professional value, in part at least, arises from the knowledge obtained through these media. Our leading firms might well consider this point, not only as in the past in connection with special researches, but with a view to contributing on a wider basis to the services rendered by such institutions.

### Restoration of Pre-war Practices.

The case of C. R. Bates, of the Amalgamated Society of Engineers, against the Bentley Engineering Company, of Leicester, which was noted recently in our columns, was reheard last week by the Local Munitions Tribunal at Leicester. The question involved was whether the defendants were entitled, notwithstanding the terms of the Restoration of Pre-War Practices Act, 1919, to continue to employ female labour in the manufacture of screw gauges. The case, when it first came before the tribunal, in May of this year, was decided against the defendants on the ground that prior to the war screw gauges were made by male labour. On appeal, Mr. Justice Roche remitted the case back to the tribunal for further consideration, and directed them to take into account the changes which had been effected in the method of manufacture. To quote from the official report—he held that the question whether a trade practice ought to be restored or introduced, in terms of the Act, depended upon whether the process of manufacture of the article was the same, and not upon whether the result of the process of manufacture was the same. If there was a practice to do a certain operation by a certain class of labour, a mere improvement of method in the performance of that operation would not prevent the practice continuing to render its restoration unnecessary; but if one method of manufacture were abandoned and a different method or process of manufacture substituted, a custom or practice which was applicable to the one method would no longer be applicable to the other method. The tribunal had accordingly to reconsider the case in the light of these directions in law. At the commencement of the re-hearing the complainant withdrew the complaint so far as it related to the inspection of the gauges and another, minor, operation, and the only matter left in dispute was the operation of the screw-cutting. The complainant stated that he had no further evidence to lead on this subject, but he proposed to lead evidence as to the pre-war methods of manufacturing screws. The tribunal ruled this out of order, on the ground that the complaint related to the manufacture not of

screws but of screw gauges. The defendants then led expert evidence to the effect that the process of screw-cutting on the new semi-automatic machinery used by the defendants was entirely different from the pre-war method of screw-cutting by the skilled man on a centre lathe; and they maintained that the pre-war custom of employing skilled men on the work had therefore no application to the new conditions and that they were entitled to retain the women on the work. The evidence for the defence was overwhelming and was accepted by the majority of the tribunal—the workers' assessor dissenting—and the complaint was accordingly dismissed.

### The Handley-Page Aeroplane Wing.

The chief claim which aerial transport has on the commercial world is undoubtedly that it affords a considerable saving in time in comparison with other means of transit. It therefore follows that the greater the saving in time, provided it can be effected at a reasonable cost, the more rapidly will aerial transport develop, so that any means provided to render high-speed flying safe and economical should be welcomed by the aviation industry. With heavier-than-air craft, one factor which has hitherto put a check on the practical use of very high speeds is that, since the range of speed is limited, high maximum speeds involve the use of high landing speeds, and high speeds are necessary for getting off the ground. That this must be so follows from the consideration that the speed of an aeroplane flying horizontally, with a given wing loading, is at all times inversely proportional to the square root of the lift coefficient of the wings. This coefficient, of course, varies with the wing section and with the angle of incidence, but it will be evident that it must have a low value for high speeds and *vice versâ*. High speeds are thus not limited by the lift coefficient, since this can be made as small as is desired by reducing the angle of incidence, the lift coefficient becoming zero for most wing sections at an incidence of about — 2 deg.; the upper speed limit is fixed by the power available for overcoming the air resistance. The lowest speed at which the machine can fly is, however, dependent upon the maximum value of the lift coefficient, and the fact that this cannot be increased indefinitely sets a limit to the minimum flying speed. With an ordinary wing section, the maximum lift coefficient is about 0·6 and is obtained with an angle of incidence of about 14 deg., after which the lift diminishes as the angle of incidence is further increased. Messrs. Handley Page, however, have recently been experimenting with a wing section with which, we understand, lift coefficients three or four times as high as usual have been obtained in wind-channel experiments, and it should therefore be possible to obtain a much wider range of flying speeds with a smaller wing area than is at present required. The wing is of the usual general outline, but it is formed with longitudinal converging slots extending upwards and backwards from the lower surface. The shape of the slots is such that, in end elevation, the wing would appear to be composed of five or six thick aerofoil sections placed one behind the other at very large negative angles of incidence, with a final aerofoil at a small angle of incidence forming the trailing edge. The effect of the arrangement is greatly to increase the stalling angle, at which the lift begins to diminish as the angle of incidence is increased, the lift, in fact, continuing to increase up to angles of about 40 deg. In the absence of exact aerodynamical data, we can only surmise that the wing behaves as a single aerofoil at small angles of incidence giving a somewhat diminished lift, but that, at large angles, the separate sections act as independent aerofoils, each contributing its quota to the total lift. We have no information as to how the drag compares with that of an ordinary section, and that is, of course, of considerable importance in connection with the maximum speed. At a public demonstration at the Cricklewood Aerodrome last week, two D.H. 9 machines were flown, one of which was fitted with the new wing and the other with the usual R.A.F. 15 section. The former, however, had only one slot near the leading edge, so that the full effect would not be obtained, but the landing speed of the machine to which it was fitted was distinctly lower than that of the other machine. We were informed that the landing speed had been reduced from 44 m.p.h. to 35 m.p.h. by the alteration of the wing. The idea certainly seems promising, and we await with interest the further particulars which will be given in a paper to be read before the Royal Aeronautical Society by Mr. Handley Page, in February next.

### Sewage Disposal in South Africa.

In a paper recently read at the North-West District Meeting of the Institution of Municipal Engineers Professor A. E. Snape described certain methods of disposing of water-borne sewage practised in South Africa. In that country it is seldom possible to discharge an effluent into an existing stream, in part because many of these are liable to run dry for many months, but also on account of certain peculiarities of the Roman-Dutch law which confers on the riparian owner very far-reaching rights. As interpreted by the courts these rights preclude the passing into a natural watercourse of effluents fulfilling even such standards as have been laid down by the Royal Commission on sewage disposal. In short, no upstream proprietor has the right to discharge into such a watercourse any effluent which will render the water unfit for domestic purposes. Hence the aim in sewage disposal in South Africa is to have no effluent and this end, thanks to the warm sun and the large area of land available is successfully attained. The sewage is treated on a large area of land which is in turn surrounded with "buffer" lands and there is no run off. The plan followed is to pass the sewage through a screen and a grit chamber, by which large floating matter and heavy mineral material is removed. Thence the sewage passes into a sedimentation tank designed so as to bring down in the form of sludge as much of the suspended solids as possible. These tanks must not be "septic" since the effluent is passed on to land and utilised for growing crops. A "septic" effluent absorbs oxygen, and thus minimises the aeration of the roots of any crops to which it be applied. The sludge from these sedimentation tanks is, however, passed into septic tanks where it separates into two forms, scum and sediment. The septic liquor between the two is very foul and is run off on to specially prepared land. In time the layers of scum and sediment meet in the tank which is then closed down, and the sludge dug out and dried in the sun. Alfalfa is said to be specially suited for cultivation on these South African sewage farms. It grows quickly, is a valuable fodder and can be cropped every six weeks. At Wynberg the return from this crop is 60*l.* per acre per annum. South African sewage is very concentrated, as shown by the following comparative figures:—

| | Total Solids. | Dissolved Solids. | Chlorine. | Total Nitrogen. |
|---|---|---|---|---|
| Birmingham ... | 196 | 139 | 20 | 7·7 |
| Johannesburg ... | 480 | 151 | 26 | 38.0 |

Great care is therefore necessary in the tank treatment. At Pretoria the sludge is discharged daily into open septic tanks, and at the end of 24 hours the liquor between the sludge and the sediment is run off for treatment as above described. The septic tanks are in duplicate and are used on alternate days. Moreover, at the end of 12 months' working each tank is given a 12 months' rest, during which the sludge is dug out and dried as already explained. The smell during this process is said to be insignificant and entirely local. The sun-dried sludge contains 3 per cent. of fixed nitrogen. It is mixed with phosphates obtained from the abattoirs of the city and from dead animals such as cats and dogs and horses, which were previously burned. It then sells readily at 10*l.* per ton.

---

New Mollier Diagram for Steam.—Messrs. W. Heffer and Sons, Cambridge, have issued a new total heat entropy chart for steam, which has been drawn by Mr. J. Case from tables compiled by Mr. J. B. Peace. Unfortunately nothing is said as to the basis of these tables, and as many of the older formulas give mutually inconsistent results, the omission is to be regretted. The chart is plotted to pound-centigrade-units and measures about 14 in. square. Its issue price is 1*s.*

## COLLOIDS.

In the course of the last few years, the Faraday Society has done valuable work by organising meetings at which matters of scientific interest have been discussed jointly by its own members and the members of kindred societies, and on Monday last a meeting of this kind was held, at which "The Physics and Chemistry of Colloids and their Bearing on Industrial Questions" was dealt with by the Faraday Society and the Physical Society of London. The meeting took place in the Lecture Hall of the Institution of Mechanical Engineers, and previous experience having shown that meetings of this kind are liable to extend beyond the usual hours, arrangements were made to devote the whole afternoon and evening to the discussion. Sir Robert Hadfield, Bart., F.R.S., took the chair at 2.30 p.m., and was afterwards succeeded by his fellow-president, Sir William Bragg, F.R.S. In spite of the gain of 2 hours, secured by the early opening, the meeting only dispersed at 10.40 p.m., the members present being even then very ready to continue the discussion.

More than 20 papers were discussed, and the early hour proved a decided success. Even if there was more about the bearing of colloids on industrial questions than about actual industrial colloid processes themselves, the reader will find very useful hints in all the papers. Science has undoubtedly yet to work out many colloidal problems. If it should prove generally possible, however, to precipitate certain compounds merely by a trace of starch, for instance, without the use of other chemicals leaving a by-product, we may look forward to notable advance.

A few notes on the nomenclature of colloid-workers may be acceptable. Many of the terms in use date back to Thomas Graham, though his general distinction of "crystalloids," the solutions of which pass through the walls of a dialyser (a filter, a membrane, porous porcelain, collodion), and "colloids" which cannot pass, has practically been abandoned. Some colloids certainly can crystallise, many colloids can be dialysed. We speak of "colloidal state" rather than of colloids, and when the qualitative work of Graham was later taken up quantitatively on the Continent, with the aid of the ultra-microscope of Zsigmondy and Siedentopf and other perfected instruments and methods, the problems appeared under new aspects, conveniently explained with the help of new, not always well-chosen, terms. The collective name colloids was retained though substances like coal, cellulose, leather, clay, glass and cements are not much like glue. In these materials the colloids appear more or less solidified; in our studies we trace transitions from the solid state into the liquid, and *vice versâ*. Ultimately we can only conceive solid particles; it is a question of subdivision. A true molecular solution of a solute (common salt, *e.g.*) in a solvent (water) is assumed to be a homogeneous, one-phase system. Very concentrated sugar solutions approach the colloidal state, which is more or less distinctly heterogeneous, a two-phase system. The solvent then constitutes the "continuous medium," the colloid particles in the pseudo-solution or "sol" constitute the "disperse phase," and are called "hydrosols, alcosols, or organosols," when the solvents are water, alcohol or organic compounds. When the particles are coarse, we speak of "suspensions and suspensoids," when the particles are themselves liquid, of "emulsions and emulsoids" (*e.g.*, oil in water, or water in oil). When acid is added to the true solution of a silicate, the solution becomes colloidal, and the silica "coagulates" or "gelates," turns into a "gel" (jelly), which when dried is gritty and not again soluble in water; in many other cases the dried gel remains soluble. The colloidal particles carry electric charges, due either to friction (from the preparation by agitation) or to the adsorption of ions (from electrolytes present). The repulsion between the equal electrification of the particles of the same colloid helps to "stabilise" the colloid (preventing its settlement). Oppositely-charged colloids mutually precipitate or coagulate one another. But there may be precipitation by particles of the same charge, whilst "protective colloids" prevent the coagulation

which on the whole resembles a crystallisation and can be started by the addition of germs. By "peptisation" a hydrogel may be converted back into a hydrosol. All these things are not so simple, however, as we have briefly put them, and investigators rather hesitate to tie themselves down to strict definitions.

### Survey of the Physics and Chemistry of Colloids.

In taking the chair and welcoming Professor The Svedberg, of Upsala, who delivered the general introductory address, Sir Robert Hadfield dwelt on the importance of Swedish scientific work of the eighteenth and nineteenth centuries. Professor Svedberg is an authority in the field of colloids and known particularly for his investigations of organosols. His short survey—which we reprint, slightly abridged, on page 587 of this issue—was a masterly exposition of the problems which he well introduced by the words: "The science of colloids is a science of the microstructure of matter." We shall follow in our comments the grouping of the papers on the agenda.

### Emulsions and Emulsifications.

Opening this part of the discussion Professor F. G. Donnan, F.R.S., of University College, London, defined an emulsion as a system in which one liquid was dispersed in a second liquid. Dilute emulsions of hydrocarbon oils, prepared by shaking the oil with pure water in a silica vessel, possessed a high stability, ascribed to the formation of an electric double layer preventing their coalescence, and on a rougher scale all the properties of suspention colloids, including the influence of the presence of ions (positive and negative) and of oppositely-charged colloids on the interfacial potential difference and the stability. Emulsification was greatly aided by the presence of a third substance, an emulsifier (soap, gums, gelatin) which formed a protecting film or membrane round the globules of the dispersed fluid. Basic salts of copper and iron (Pickering), even soot, would serve as emulsifiers. The interfacial adsorption and concentration of the emulsifier at or in the interfacial layer leading to the formation of the protecting film was thus very important, though the effects of the double layer on the differential adsorption of ions could not be neglected. Very interesting phenomena occurred when an emulsion "inverted," *i.e.*, when on further addition of the dispersed liquid (oil) this oil interchanged its role with what had been the continuous medium (water). This change of type was readily detected by the sudden change of electric resistance. In the case of hydrocarbon and fatty oils emulsified in water by the aid of soap it had been shown that electrolytes influenced the inversion point. Trivalent and divalent cations tended to make the oil the continuous phase, whilst monovalent ions, especially alkali hydrates, tended to disperse the oil in the aqueous phase; the determining physical factors were not yet completely elucidated. The study of emulsions had thrown much light on the phenomena exhibited by colloidal systems, though the very much larger size of the dispersed particles and the correspondingly diminished Brownian movements even of the finest emulsions differentiated them in many respects from colloidal solutions.

The point on which Mr. Shanti Swapura Bhatnagar, of University College, London, dwelt in his paper on "Reversal of Phases in Emulsions and Precipitation of Suspensoids by Electrolysis: An Analogy," is best understood by our referring to emulsions of Class I (oil in water) and Class II (water in oil). The two cases can be distinguished by the colour indicator method of Robertson (the Soudan III dye colours only the oil globules of I, while in II the whole liquid appears coloured) or by the drop method of Briggs. Neither method being very satisfactory, Mr. Bhatnagar studied the effects of adding drops of electrolytes to oil emulsions containing some soap solution, watching for the sudden drop in the conductivity of the mixture which marks the inversion of case I into case II. Mr. Bhatnagar found that the power of reversing the phases in these electrolytes decreased in the order *Al*, *Cr*, *Ni*, *Ba*, *Sr*, *Ca*, *K*, *Na*, *Li*, trivalent ions being thus more powerful than divalent and monovalent ions, and this order was the same as in suspensoids. The results had a bearing on the cleansing power of soaps which Chevreul ascribed to the free alkali liberated, but which Mc. Bain and others attributed to the efficiency of the soap for binding the dirt and grease in an emulsion.

Since Mr. William Clayton, M.Sc., introduced his paper on "Emulsion Problems in Margarine Manufacture" by the remark that margarine manufacture offered a splendid field for colloid research, our readers will not object to our referring to margarine, in which we are all interested, and in the manufacture of which the engineer has a share. In margarine, Mr. Clayton pointed out, certain animal and vegetable oils and fats replacing butter fats were liquified and then churned with soured milk to form an emulsion; the emulsion was cooled by sprays of ice-cold water under pressure or by flowing over cooled revolving drums, and the product was kneaded. The suitably-phased emulsion contained from 77 per cent. to 89 per cent. of fat, the rest being milk serum (water). The milk was used at 7 deg. C., the melted fats at 40 deg.; the emulsion had before chilling a temperature of 24 deg., the chilling was to produce the fine-grained condition. The emulsifying machines were either jacketed tanks, with hot or cold water circulation, or continuous churns. In the tank the milk must be admitted first, and the oil then run in slowly to make the emulsion fine-grained as in the oil-in-water type and permanent. If the order were reversed, or fat and milk were placed in bulk in the churn before the agitation was started, a water-in-oil emulsion was produced which was not permanent. The continuous churn economised space, time and power; oils and milk were simultaneously admitted and discharged in a continuous stream, but the control was not so easy as with the tank, and the type of emulsion might be reversed. Violent agitation was generally preferred to occasional shaking; according to Briggs, however, intermittent shaking was vastly more effective than uninterrupted agitation, even six-hundred or one thousand times more effective. As regards the "breaking" of emulsions of oil in soap solution by sodium chloride Mr. Clayton suggested that by preferential adsorption of the Cl-ion at the oil-water interface caustic soda was formed which united with free fatty acid present to form a soap. Experiments made by him at the works of Calder's Margarine Company (Liverpool) showed that 2 per cent. of salt (reckoned on the margarine, 13 per cent. on the aqueous phase) facilitated emulsification.

The other paper by Mr. W. Clayton, M.Sc., on "Coagulation of Inorganic Suspensions by Emulsions" is also of considerable technical interest, though for commercial reasons he did not explain the nature of the inorganic solids with which he has experimented, and which we will designate by the letters A and B. They form stable aqueous suspensions which are not affected by boiling, but are precipitated by very small quantities of starch and also by frothing agents like tannin, dextrin, milk, egg albumin, urine, &c., all of which reduce the interfacial tension between the disperse phase and the medium. That is the curious point; in Bredig's preparation of metallic colloids producing sparks under water between the electrodes of the metal, such substances are purposely added to increase the stability of the colloidal solution. Clayton found that when he suspended A in diluted hydrochloric acid and gradually added starch solution under continued stirring, the particles suddenly coagulated and sank rapidly; in this case the electric charge on the solid A was negative, the charge on the starch was positive. When A was suspended in pure water, the charges were both negative, yet coagulation also took place. In the former case the amount of starch needed was 0·025 per cent. for 10 per cent. of A. Solid B gave similar results, though entirely different from A chemically. The preparation of the starch was important; it was prepared by boiling the starch with a very diluted solution (0·3 per cent.) of caustic soda. When the starch was simply boiled with water, it proved unsatisfactory, and when boiled with slightly acid water, it was still more unsuitable. China clay, talc powder, ore slimes and magnesium carbonate were coagulated like A and B; of the frothing agents urine proved very active throughout, tannin failed in acid solutions.

### Physical Properties of Elastic Gels.

The introduction of this subject by Mr. Emil Hatschek, lecturer at the Sir John Cass Institute, E., deviated—to meet arguments of some papers presented after his own—a good deal from his printed paper, part of which we reproduce on page 574 of this issue. The points which Mr. Hatschek emphasised were the importance of the study of mechanical properties and of non-aqueous gels free of electrolytes. Working with aqueous gelatin had many advantages, but also drawbacks. He had succeeded in producing a rubber gel, apparently very stiff, by vulcanising rubber in benzene solution with sulphur chloride; this gel (exhibited) could be hardened with formaldehyde.

Professor H. R. Procter, D.Sc., of Leeds, speaking on "The Structure of Jellies," said that though he agreed with most of Mr. Hatschek's remarks, he adhered to the third of the possible structures of gels: (1) a simple emulsion of more or less distorted globules in a liquid medium; (2) a sponge-like structure containing in its pores the suspension liquid or liquid solution, two-phase in the sense that the pores are of microscopic, and not of molecular dimensions; (3) a more or less solid solution of the exterior solution in the colloid, both constituents being within the range of the molecular attractions of the mass and in chemical and electric equilibrium with the external liquid (if any), such a solid solution, therefore, constituting a single phase in equilibrium with a real or virtual external solution. One of his points was that the jelly would swell indefinitely if not restrained by an opposing force, in accordance with Hooke's law that the stress is equal to the strain. The network of the jelly would be very open. The setting would consist in the formation of crystals, possibly flexible, and the slow increase in the viscosity would depend on the slowness of crystallisation. All commercial gelatins were too impure for attempting calculations of molecular weights. During the discussion by Professors Donnan McBain, McC. Lewis and others, Professor Svedberg, mentioned that coarse emulsions of mercury and of other substances of high surface tension could be produced by passing the mercury through a capillary into water, and very fine emulsions by forcing the water through a capillary (in both cases the end of the tube in the liquid was bent upward) into mercury; in the case of oils the two methods gave practically the same result.

Dr. S. C. Bradford, of the Science Museum, London, referred in his paper on "The Reversible Sol-gel Transformation," first to the well-known case of Liesegang figures studied by H. Bechhold in 1905*. A gelatin solution is impregnated with ammonium bichromate and allowed to set to a jelly; a drop of an aqueous solution of silver nitrate falls on the jelly; the jelly surface turns yellowish, and a system of orange-brown rings of silver chromate, becoming more crowded and fainter at greater distances, surrounds the spot. The gelatin takes up the water and the very slightly soluble silver chromate is precipitated; some ammonium nitrate is liberated in which the silver chromate is more soluble; thus supersaturation and precipitation succeed one another in rythmic sequence. The experiment can also be made in water and more conveniently by letting the silver nitrate drop on blotting paper, but both the cellulose of the paper and the gelation are colloids and are concerned in the reaction. For one thing the setting point of the jelly is raised or lowered by the salts used. These and similar experiments show the sentiveness of supersaturated solutions to electrolytes, and Dr. Bradford suggested that suspensorial solutions corresponded more clearly to metastable solutions and emulsoid sols to true solutions. In support of this he dwelt upon the

* It is interesting to mention that a book on blotting-paper figures, obtained by dropping inks, salt solutions, &c., on the paper, was published by F. F. Runge, the discoverer of carbolic acid, in 1855. The figures resembled forms of low-organisms. Very beautiful examples of crystal growth, recalling forms of plant and animal life, were obtained within recent years by the mutual precipitation of salts in very diluted undisturbed solutions.

experiments of Weimarn—confirmed by his own experiments—demonstrating that gels (on cooling) and sols (on heating) yielded precipitates which might form (1) large crystals in the course of years, (2) ordinary crystals in a short time, (3) growth-figures and needles, (4) amorphous grains or microscopical spherites, (5) a gel which so far could not be differentiated. Thus all the phenomena of gelation indicated a connection with crystallisation; that view explained the viscosity changes in sols and gels according to Einstein, and Debije and Scherrer had proved the crystalline nature of some sols by X-ray examination. There was hence good reason for regarding the reversible sol-gel formation as an extreme case of crystallisation.

In his short paper on the "Structure of Gels" Dr. J. V. Wakelin Barratt, M.D., of London, contested the current view that gels consisted of fluid droplets enclosed in a solid framework somewhat comparable to a honeycomb. That idea seemed to have its origin in the apparently similar structure of the stems of young plants which possess considerable rigidity and elasticity in spite of their containing as much as 90 per cent. of water. Optical examination, however, did not show liquid droplets enclosed by solid septa, but a mass of intersecting fibrils running perfectly straight and united at their points of intersection (Zsigmondy and Bachmann). The nature and mode of formation of the fibrils was controversial; Stübel had pointed out their superficial resemblance to linear crystals. Dr. Barratt himself considered that they were formed before becoming visible when increasing in thickness. Excessively fine fibrils appeared dry and rigid; coarse fibrils of smaller number appeared moist and elastic. That fibrillary network structure would help us to understand the possibility of a diffusion and filtration of gels.

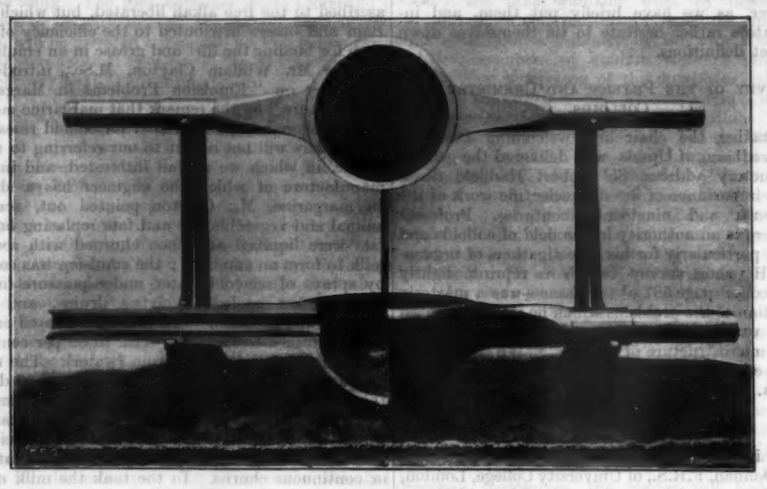
Professor T. W. McBain mentioned that according to experiments by Miss M. E. Laing, soap solutions, the simplest gelatinising colloids, existed in three states: a viscous liquid or sol, (2) a transparent gel, (3) a white curd; (2) and (3) were quantitatively identical (except mechanically), and that was incompatible with all theories of gel structure, except the micellar theory of Nägeli and Zsigmondy. The colloidal particles of (2) and (3) were the same, but independent in (2), and linked up in (3). The neutral soap separated out in the curd, and the photographs exhibited showed the fibrils in the curds very well. An observation quoted by Professor Svedberg exemplified the delicacy of some gel structures. Recently one of his students had prepared a cadmium hydrosol in water which turned into a jelly; but when a glass rod was moved in the jelly, the whole mass liquefied.

*(To be continued.)*

"Advertising."—A course of five lectures on "Advertising," by Captain Oliver A. Minns, will be given on five successive Mondays, at 7.45 p.m., commencing on Monday, November 8, at the Commercial Evening Institute, Stillness-road L.C.C. School, Honor Oak Park, S.E. 23. The fee for the course is 2*s.* 6*d.* Applications should be forwarded to the Principal of the Institute.

International Shipping, Engineering and Machinery Exhibition.—The arrangements for this exhibition, to be held in 1921, are well advanced, and a committee of experts has again been formed comprising practically the whole of those who acted before. The first meeting of this committee was held on the 5th inst., when Mr. F. W. Bridges announced that a large number of well-known eminent gentlemen connected with shipping and shipbuilding interests had given their patronage, including Lord Aberconway, Lord Armstrong, the Marquis of Ailsa, Viscount Fielding, Sir Charles A. Parsons, Sir Robert Hadfield, Bart., Admiral Sir George G. Goodwin, Engineer Vice-Admiral Sir Henry J. Oram, and that Lord Weir of Eastwood, Sir Archibald Denny, Bart., Sir E. H. Tennyson d'Eyncourt, Sir Alexander B. W. Kennedy, Sir Herbert Rowell, and Colonel R. Saxton White, had accepted the position of vice-president, while Sir Herbert Rowell, of Messrs. R. and W. Hawthorn, Leslie and Co., had intimated his willingness to accept the position of chairman of the honorary committee of experts. Mr. Bridges further stated that a large number of applications for space had already been received, and that many exceedingly interesting exhibits had been promised. Certain details of organisation were discussed, and it was unanimously agreed that priority should be given to British firms, and especially to those showing machinery in motion and demonstrating processes. The exhibition offices are at 36 and 38, Whitefriars-street, Fleet-street, E.C. 4.

# STEEL FORGED BACK-AXLE FOR MOTOR VEHICLES.



One of the weak points of the ordinary live axle lorry has been the construction of the actual axle casing, which has either been a banjo frame forging or a casting, neither of which are entirely satisfactory. The Butler Davis patent axle, which was shown at the recent Commercial Motor Show by the Kirkstall Forge Company, Limited, of Kirkstall, Leeds, is of considerable interest. We illustrate this axle in the accompanying figure, which shows one complete axle as viewed from the top and a side view of one with the half-length in section to show the construction. It will be seen that the axle is a steel stamping going right across from wheel to wheel, in a similar manner to the ordinary banjo frame type. In place of having the banjo frame in the centre, however, with an oil cover bolted on the bottom, the oil cover is stamped in one piece with the rest of the axle. This has many advantages over either the cast axle or the banjo frame type. The former is necessarily heavy and has to have separate parts at the ends either bolted on or pressed in to form the wheel bearings. This means extra expense in manufacture, and again extra weight in the flanges and connections. Further, cast axles are always liable to crack. The forged banjo frame type is free from the above objections, but the hole in the centre necessary for the differential makes the structure a weak one, and therefore it must be heavy to avoid distortion.

In the Butler Davis axle both these weak points are avoided. The centre of the axle is very greatly stiffened by the bottom half of the casing being forged in, and at the same time can be made lighter than the banjo frame of the ordinary forged type of axle, while all the advantages of the latter form of construction are retained. The axle can be built up into either worm-drive type or double reduction. It is made in various sizes, the larger ones for heavier lorries and the smaller for light vans and cars. This axle should make an exceedingly satisfactory job and be a distinct advance on ordinary construction, especially in heavy lorry work where a considerable amount of weight should be saved. Weights are always a matter of importance in vehicle work, but axle weight is especially so for the axle is a deadweight and not carried on the springs, and there is no doubt that unsprung weight is a very serious matter for many reasons. Up to date the main advantage that the chain-driven lorry has had over the live-axle type has been that the unsprung weight is less, and therefore every effort should be made to keep the weight of live axles as low as possible.

British Chamber of Commerce, Switzerland.—The British Chamber of Commerce for Switzerland has begun work, and has taken convenient premises at 20, Rittergasse, Basle. The permanent Secretary-General is Mr. Alexander Richardson, the branch office at Place St. François, Lausanne, being in charge of Mr. Maurice Galland. The need of a British Chamber of Commerce for Switzerland is recognised by both British and Swiss business houses, the opinion being general that now is the right time to consolidate Anglo-Swiss commercial relations by every possible means. Most other nations doing business with Switzerland have their Chambers of Commerce in the country, and it certainly is time for Great Britain and her Colonies, who buy more from Switzerland than any other nation, to have corporate representation on the spot.

## "TIME AND LIME."

To the Editor of Engineering.

Sir,—Your correspondent in the current issue of Engineering is right in the wording and in the present meaning of the expression "Time and Lime." The original meaning, however, was not labour and materials, but literally time (or men's wages) plus lime (or mortar) only, and it has reference to cases where the purchaser provides the stones or bricks and the builder was paid for the labour and mortar. Such, at any rate, is my recollection of the matter. The expression is one with which the C.E. or structural apprentice early becomes acquainted. "Cape and corner" is another. Their oddness passes off with use.

Yours faithfully,
Wm. Burnside.

Personal.—Messrs. Cross, Son and Robertshaw have been appointed sole selling agents for Wild-Barfield electric furnaces for the counties of Northumberland, Durham, Cumberland and Yorkshire. In addition to their office in Newcastle, Messrs. Cross, Son and Robertshaw have opened a branch office at 41, Great George-street, Leeds, where a demonstration furnace is in course of erection. Messrs. Macbeth Brothers and Co., Limited, Bombay and Calcutta, have taken over the sole selling rights for India where these plants are already in operation.—Messrs. Sir Isaac Pitman and Sons, Limited, are leaving their present publishing offices at 1, Amen Corner, and are removing to 39 and 41, Parker-street, Kingsway, W.C. 2.

University College, London.—The calendar for the ensuing academic year at University College, London, has now been issued. The faculties are those of Arts, Laws, Science, Engineering and Medicine. Professor E. G. Coker is Dean of the Engineering Faculty, the vice-dean being Professor J. A. Fleming. This faculty includes departments of civil and mechanical engineering, electrical engineering and municipal engineering. The courses are, it may be added, suited to the requirements of students proposing to enter the Indian Public Works Department, and the Government engineering services in this country. The course of instruction extends over three years, but provision is also made for post-graduate work, in connection with which special courses of lectures have been arranged for. Amongst these may be noted a series of six advanced lectures by Professor Fleming on "Wireless Telegraphy and Telephony by Continuous Waves."

Institution of Naval Architects.—The date for the opening of the next annual meetings of the Institution will fall on Wednesday, March 16, 1921. The council desire to draw the attention of members to the scholarships in naval architecture and marine engineering which will be available for competition in 1921 and 1922 among apprentices in H.M. Dockyards, private shipyards and Marine engineering works. The council hope that members who are connected with shipbuilding establishments will make these known as widely as possible among their apprentices, in order to extend the field of usefulness of these scholarships, which are due to the generosity of the firms that have offered them. Full particulars of these scholarships can be obtained on application to the secretary. The scholarships are as follow:—*Scholarships in Naval Architecture*; 1921—Institution of Naval Architects, 100*l.*; Beardmore, 150*l.*; Fairfield, 150*l.* 1922—Elgar, 100*l.*; Cammell Laird, 150*l.* *Scholarships in Marine Engineering*; 1921—Yarrow, 100. 1922—Parsons, 150*l.* (the seven are per annum and for three years.) *Post-Graduate Research Scholarships*; 1921—1851 Exhibition Commissioners, 250*l.* 1922—1851 Exhibition Commissioners, 250*l.*; Sir William White, 150*l.* (The three latter are per annum and for two years.)

## THE INSTITUTION OF MECHANICAL ENGINEERS.

*Abstract of Address by the President*, Captain H. Riall Sankey, C.B., C.B.E., R.E. (Ret.).*

A number of papers have been read or will be read before this and other engineering institutions dealing with the application of engineering during the Great War. As I was privileged to be officially connected with certain sections of engineering work during the war, I thought that some of the non-confidential information which I thus obtained might form the subject matter of my Presidential Address, and it might thus be one of the group referred to above.

The catch phrase, so common in the early days of the war, "This is an engineers' war," was undoubtedly substantially true, and in a greater measure in this than in past wars. It is generally supposed that there is a clear-cut division between Military Engineering and Civil Engineering (in the broad sense of the Charter of the Institution of Civil Engineers), but it is, nevertheless, impossible to say where, in the Great War, military engineering ended and civil engineering began. It will be agreed that at the front trenches it was purely military engineering, and that in the back areas it was the application of civil enginering to the purposes of war. The difference between this and its ordinary application lies in the change of the relative importance of economy of construction, the time required for the work, and the reduced factor of safety.

In military operations time is the ruling factor, and economy of construction is subservient. Nevertheless, economy in the broad sense was observed, because exorbitant cost, if it results in the construction of some engineering structure or in the supply of some munition of war by the time required, may greatly affect, or even decide, the issue of an operation on which the whole successful termination of the war may depend. The above must not be construed as a premium on extravagance, but rather to indicate the nature of the financial decisions that have to be made by those responsible for the conduct of engineering matters during the war.

Of all the forms of engineering, mechanical engineering had the lion's share, both as regards the volume of work done and expenditure. As a proof of this statement, one need only consider what could have happened if the mechanical engineers had been removed. As a general statement, it may be said that the essential object was to throw "stuff" at the enemy, and that stuff, whether bullets, shells, bombs, poison gas or flames, was made by mechanical engineers or by machinery supplied by them. The apparatus for throwing the stuff, whether rifles, guns, projectors or aeroplanes, was made by mechanical engineers, and, lastly, they were intimately concerned with the means of transporting the stuff and the apparatus from the workshop to the position where used, whether by means of motors, lorries, railways or steamships.

Apart from mechanical engineering, mechanical engineers in general, and the members of this Institution in particular, rendered other services to the country which cannot be exaggerated, and the Roll of Honour is an eloquent testimony of such services. As already stated, every branch of engineering contributed to the final and satisfactory issue of the war, but in this Address I propose to limit myself to that portion of mechanical engineering of which I have had experience during the war, or on which I have been able to obtain information, both in France and at home.

The work of the Mechanical Engineers at the Front was carried out principally by the R.A., the R.E., R.A.S.C., R.A.O.D., the Air Force, and the railways, and, in general, the class of work done by each was as follows:—

### Machinery Subject to Repair in Use by Various Corps.

*Royal Artillery.*

Guns and gun carriages, various mechanical lifting appliances, range finders.

*Royal Engineers.*

Steam engines (stationary and portable), oil engines, petrol engines, electric generators and motors, pumps of all kinds, ventilating fans, mining and digging machinery, hydraulic pumps and rams, printing and lithographic machinery, stone crushers, branch railway material of all kinds, and telegraph, telephone and wireless apparatus.

*Royal Army Service Corps.*

Horse-drawn wheeled vehicles, motor cars, petrol engines, laundry and bakery machinery, stationary steam and oil engines, tractors for guns of various calibres.

*Mechanical Transport.*

Steam and petrol tractors, mechanical wheeled vehicles.

*Railways.*

Locomotives (normal and narrow-gauge), wagons of various types (normal and narrow-gauge), petrol and petrol-electric tractors.

*Tank Corps.*

Petrol engines and gear.

In the early days of the war the extent to which mechanical engineering would be employed was not realised, which is evidenced by the fact that repair shops of any magnitude were only started at the beginning of 1917, but then rapidly developed both as to numbers and size into a huge organisation. I propose to say a few words about some of these repair shops erected on the French front, most of which I had an opportunity of inspecting.

As a rule the buildings were of a temporary nature, but in some cases existing buildings were adapted. The machines and tools were of the best description, and the lay-out and organisation was quite on a par with the best works at home. Some of the principal works erected were as follows:—

*Locomotive Repair Works*—These were divided into works to deal with the normal-gauge stock and with the light railways, principally 60 cm. gauge. In the early days of the war the British Headquarters Staff did not anticipate a heavy programme of railway construction, it being expected that this work would be done by French troops, and the intention was for the British troops to assist the Belgians in repairing the lines through Belgium.

Some idea of the magnitude of the railway operations will be gathered from the fact that in an area approximately 10 miles broad by 10 miles long, south-west of Ypres, there were established 200 railway stations, both normal and narrow-gauge. The total mileage of normal gauge laid by the British troops during the war on all counts was 2,639 miles, and, owing to heavy traffic and enemy action, the repairs of the rolling stock was very great, as will be gathered from the following table:—

*Locomotive and Wagons (Normal Gauge) Provided by the British (Totals at the dates given).*

| | Dec. 31, 1916. | Dec. 31, 1917. | Dec. 31, 1918. |
|---|---|---|---|
| Locomotives— | | | |
| Imported | 62 | 753 | 1,205 |
| Hired | 198 | 215 | 229 |
| Captured | — | — | 6 |
| Total | 260 | 968 | 1,430 |
| Wagons— | | | |
| Imported | 3,840 | 34,845 | 52,597 |

The first provision for the mechanical engineering in connection with the railway construction troops was on a very small scale, and consisted of the appointment on September 29, 1914, of an officer with the rank of captain, whose duty it was to cope with the erection, preparation, operation and maintenance of special plant, such as pile drivers, breakdown cranes and pumping plant. In December, 1916, the right half of a new R.E. Company, No. 108, was detailed for the above duties, but was only brought to full strength in August, 1916, two years after the declaration of war.

It was only in April, 1917, that the matter was really taken up seriously, when the Chief Mechanical Engineer's Department was formed, and works were started at Audrieq and were laid out with the object of repairing some 30 Belgian locomotives and of erecting 2,500 railway wagons (ultimately increased to 10,000, shipped from Canada. The capacity of these shops was such as to be able to deal with 400 wagons per week. Later these works were extended to deal with the repairs of normal-gauge locomotives.

When the German advance of May, 1918, occurred, the Audrieq works were dismantled and the locomotive part was sent to St. Etienne, near Rouen where repair works had been established. Works nearby at Oissel were prepared for wagon repairs, with a capacity of 160 per week, in case Audrieq had to be abandoned. As a matter of fact, it was not abandoned, and therefore the Oissel works never came into operation. At St. Etienne advantage was taken of the materials already available for the construction of three bays of the railway works extension which had been projected before the war.

Work was begun in February, 1917, and the machine tools were temporarily driven by oil engines, awaiting the completion of the power station, in order to erect locomotives shipped in parts from the U.S.A. After the German advance on Amiens in March, 1918, a part of these works was handed over to the Nord Railway of France. Some of the principal work done at these shops was the erection of British locomotives, repairs of the Belgian locomotives parked at Oissel, the maintenance of R.O.D. locomotives (40 per month) and the manufacture of spares. Amongst the personnel of these shops were two Prisoner of War Companies of selected tradesmen.

Locomotive shops had also been installed at Borre, on the Hazebrouck–Poperinghe line, for the repair of locomotives working into Belgium. These works occupied 7 acres, and were capable of dealing with 20 heavy repairs per month and also manufacturing locomotive spare parts. These works became untenable owing to the German advance of May, 1918. The shops were stripped and the plant removed under shell fire in four days, and was sent to Audrieq on the way to Rang-du-Fliers, which was laid out to repair 20 locomotives per month, but was completed too late to be of any real service. The work done in the various shops is indicated in the following table:—

Output of the Various Railway Repair Shops in France, both Normal and Narrow-gauge, during 1918.

| | |
|---|---|
| *Locomotives*— | |
| Erected | 246 |
| Repairs in shops, heavy and light | 809 |
| Repairs in running shed | 5,487 |
| Washing out | 25,813 |
| *Wagons*— | |
| Erected | 3,434 |
| Repairs, heavy and light | 22,639 |
| *Ambulance trains*— | |
| Repairs | 104 |

(There were 41 ambulance trains.)

*Light Railways.*—It was only in the late summer of 1916 that a comprehensive system of light railways, principally 60 cm. gauge, was considered, and an estimate based on 1,000 miles of track was prepared. According to the position of the line, 9 lb., 16 lb. and 20 lb. rails were to be used, and the original weight of the locomotives was limited to 7 tons for the 9 lb. rails and for working on the heavier rails 14-ton Hunslet, 14·5-ton Baldwin and 17·2-ton American Locomotive Company locomotives were ordered. Electric traction was considered, but was abandoned in favour of steam. Subsequently petrol tractors and petrol-electric tractors were obtained. Of the former the 10 horse-power were suitable for trench tramways, and the 20 horse-power and 40 horse-power for the 16 lb. and 20 lb. rails for use some way behind the immediate front. Some details are given in the following table:—

Light Railways (Principally 60 cm. Gauge). Length of Track and Rolling Stock.

| | Original estimate, 1916. Miles. | Actual provision. Miles. |
|---|---|---|
| Track | 1,000 | 3,470 |
| Locomotives (steam) | 800 | 835 |
| Petrol tractors | 100 | 1,030 |
| Petrol-electric tractors | 200 | 200 |
| Double-bogie trucks | 2,000 | 3,940 |
| Steel-well trucks | 800 | 2,316 |
| Four-wheel box wagons | — | 2,350 |
| Tip wagons | 750 | 7,665 |
| Hand trolleys | — | 1,100 |
| Gun carriers | — | 224 |

The petrol tractors were found preferable in the forward areas owing to less visibility than the steam locomotives. The wagons were principally of the double-bogie type, and there were also four-wheeled box wagons. Certain wagons were arranged so that gun-carriage frames for 6 in. howitzers could be attached. The operation of attaching or detaching took 5 minutes.

The final provisions for repairs of light railway rolling stock were as follows:—

(1) A central workshop (originally sited at Aire).
(2) Six Army repair shops.
(3) Six normal-gauge mobile repair shops, consisting of machine power and air-compressor van, fitting shop, stores and an office van.
(4) Repair shop at Richborough (towards the end of the war).
(5) Two broad-gauge mobile repair shops.

Prior to the autumn of 1917 Decauville locomotives, etc., were repaired in a corner of the Audrieq yard. In November, 1916, a scheme was prepared to build a central shop near Bethune, but it was considered to be too near the enemy lines, and finally a site at La Lacque, near the Berguette Station and near to the Aire Canal, was chosen. The approval was given on December 31, 1916. Many difficulties were encountered with regard to the site and the weather, namely, frost and wind. The smith's shop was at work 177 days after approval. The first machine tool was turned round in 184 days, and the work started normally in 209 days. These works were exposed to hostile airmen and long-range shell fire, and received two direct hits. On the occurrence of the German advance in May, 1918, the locomotives were sent to England for repair, and the machinery was sent to Zeneghem for store until ready to be received at Beaurainville, where a new light railway repair shop was started in May, 1918. The first machine started running on July 21, 1918.

Important mechanical engineering work was done at various docks, such as Dunkerque, Calais, Dieppe and Havre. At Dunkerque, for instance, 40 electric cranes and 50 steam cranes were erected, as well as four transporters for discharging coal. As regards the latter post-war traffic of ore from Lorraine and coal from this country was not lost sight of, and, consequently, provision was made for placing in position and unloading a 1,000-ton ore train into a ship, charging it with 1,000 tons of coal and despatching it, the whole operation to take three hours.

The volume of traffic and its rapid increase will be realised by the statement that, at December 31, 1916, 126 cranes were at work for the British at various ports. At December 31, 1917, this number had risen to 290, and at December 31, 1919, to 360.

Aeroplane shops were erected at Pont de l'Arche, near Rouen. These shops were quite extensive, and were laid out on up-to-date modern lines. The machine shop had a complete outfit of modern tools of all descriptions of the kind required for small, accurate work. The power station consisted of oil engines aggregating 400 horse-power. The buildings were of a temporary nature.

Extensive repair shops for motor lorries were established at various places. They were known as the Heavy M.T. Repair Shops. Some particulars of these shops are given in the tables on the next page.

The magnitude of all the repair shops I have referred to gives some idea of the amount of machinery at the Front, but it must be remembered that this machinery was exposed to great risks and suffered injury from enemy fire, and was running under much more onerous conditions than in peace time, as, for example, the effect of the state of the roads on motor vehicles.

The following are a few examples of the use of machinery which I had the opportunity of inspecting:—Machinery was used at the quarries for driving the air-compressing plant for rock drills and the stone-crushing machinery. The power required at the Marquise Quarries, for instance, was 2,000 brake horse-power, and consisted of oil engines, suction gas engines and portable steam engines, also electric power obtained from the

* Delivered October 22, 1920.

| Heavy Repair Shops. | Mechanical Transport. | | | | | | |
|---|---|---|---|---|---|---|---|
| Name of Works. | 1st. | 2nd. | 3rd A. | 3rd B. | 4th. | 5th A. | 5th B. |
| Purpose .. .. Repair of | Lorries .. | Lorries and motor cycles | Motor vehicles, all classes | Motor cars and motor ambulances | Repairs to accessories and parts | Repairs to lorries | Repairs to lorries |
| Locality .. .. .. .. | Plaine St. Denis | Rouen .. | St. Omer .. | Honfleur .. | Rouen .. | Bergues, nr. Dunkerque | Rouen |
| Whether under fire .. .. | Yes. "Big Bertha" | No .. .. | Bombed intensively | No .. .. | No .. .. | Yes .. | No |
| When started .. .. .. | Sept., 1914 | Feb., 1915 | May, 1915 | May, 1916 | Jan., 1917 | Nov., 1917 | Apr., 1918 |
| When got to work .. .. | At once | At once | At once .. | Aug., 1918 | May, 1917 | Not used .. | Aug., 1918 |
| Period in use .. .. Years | 4½ .. .. | 4½ .. .. | 3 .. .. | 1—till May, 1919 | 2½—till Sept., 1919 | | |
| Type of building (whether permanent or temporary) | Permanent | Mainly permanent | Permanent | Converted timber store, galvanised, steel additions | Steel frame galvanised, sheet walls and roof | Steel frame galvanised, sheet walls and roof | Steel frame galvanised, sheet walls and roof |
| Floor space .. .. Sq. ft. | 100,000 | 85,000 | 94,000 | 108,000 | 234,000 | 120,000 | 140,000 |
| Value of machines installed .. | 5,000 | 7,000 | 8,000 | | 30,000 | 14,000 | |
| Lifting tackle .. .. .. | Light .. | Shipyard travelling crane (heavy) | Light .. | Light .. | Light .. | Light .. | Light |
| Men employed— Military .. .. .. | 800 | 800 | 800 | 500 | 250 | — | 570 |
| Prisoners of war .. .. .. | — | 500 | — | 500 | 3,500 | — | 450 |
| Quantity of work executed during the period | 4,800 vehicles overhauled | 3,920 lorries cars and motor cycles | 5,650 | — | Vehicles repaired 150, Parts repaired 2,500,000. Parts manufactured 1,050,000 | — | 550 vehicles |

*Machine Tools in M.T. Repair Shops.*
*B.E.F.*

| Machine Tools. | Repair Shop. | | | | |
|---|---|---|---|---|---|
| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. |
| Drilling machines .. .. | 8 | 7 | 11 | 25 | 23 |
| Furnaces and ovens .. | 3 | 1 | 3 | 4 | 4 |
| Grinders .. .. .. | 14 | 4 | 8 | 21 | 6 |
| Power hammers .. .. | 1 | 1 | 1 | 3 | 1 |
| Lathes of various descriptions .. .. .. | 34 | 38 | 28 | 88 | 31 |
| Milling machines .. .. | 2 | 3 | 3 | 22 | 5 |
| Shapers and planers .. | 3 | 4 | 2 | 8 | 1 |
| Presses .. .. .. | 3 | 3 | 1 | 6 | 3 |
| Power saws .. .. .. | 2 | 3 | 3 | 6 | 4 |
| Screwing machines .. | 1 | 1 | — | 3 | 2 |
| Slotting machines .. .. | — | 1 | 1 | 2 | 1 |
| Various .. .. .. | — | 4 | — | 13 | 3 |
| Wood-working machines .. | 4 | 5 | 5 | 10 | 5 |
| Totals .. .. .. | 75 | 75 | 66 | 221 | 89 |

existing power station. The output of this quarry was 6,000 tons of road metalling per day.

*Water Supply.*—The water supply to the Army was one of the most essential and important operations, and the mechanical engineer had his fair share of the work. As this subject will be dealt with at the next general meeting, I will confine myself to a few examples. At Zuytpeene there was a pumping station fitted with mechanical filtration. The water came from a stream close by and was anything but tempting. The pumping engine was of the Dennis fire-engine type, with a Mather and Platt multi-disc centrifugal pump, capable of dealing with 120 gallons per minute against a head of 500 ft. The water was treated by a Wallis and Tiernan chlorine regulator working on the ferro-alumina principle.

Air lifts were used to a large extent, and the water supply dealt with by them covered an area of 1,000 square miles. In March, 1918, there were 24 stationary air lifts at work. In some cases a portable air-compressor plant driven by a petrol engine was used, and it went from one well to another. One of the difficulties of these pumping plants was that they had to be continually removed and re-erected to meet retreats and advances. An interesting well pump was developed, originally of French design. An 8 in. loosely-woven canvas belt, long enough to be immersed in the water of the well, ran over an 18 in. pulley, driven by a small petrol engine. On turning over the pulley the water was driven off the belt by centrifugal force, and thus separated and caught.

Some idea of the total volume of work dealt with can be gathered from the table in the next column.

The R.E. workshops require special notice. Some of these were more or less permanently sited during the war and others were movable. They were divided into Army shops and Corps shops. The R.E. workshop at Rosel contained an outfit of wood-working machinery, driven by portable steam engines. An R.E. workshop was established near the canal at Arques. It comprised a small foundry, a smithy with power hammer, and an outfit of medium-sized machine tools. At Vendroux there was a very extensive R.E. yard, with 70 miles of track, in order to deal with the storing, delivery and distribution of timber of various scantlings, barbed wire, duckboards, joists of various sections, small railway bridges, and heavy bridging timbers, etc. The store sheds were steel-framed buildings of considerable height, 1,200 ft. long and 120 ft. wide. The workshops at the same place were of considerable extent. The foundry had a 10-ton, a 5-ton, and a 2½-ton cupola. The largest casting made weighed one ton. There was also a large machine shop and an extensive wood-working shop. One shed was devoted to deal with guns on railway mountings, and a 150-ton Goliath crane was erected for this purpose. Another large R.E. shop and stores was situated at Avancourt and covered 683 acres. The articles stored were similar to those referred to above. The workshops were extensive, consisting of sawmills and joiners' shops containing a large amount of wood-working machinery.

Directorate of Transportation.

*Stores dealt with during the month of July, 1918.*

| | |
|---|---|
| Landed at French ports ... | 169,741 D.W. tons. |
| Channel Ferry— | |
| To France ... ... | 5,588 D.W. tons. |
| From France ... ... | 890 D.W. tons. |
| *Railways*— | |
| Loaded wagons, normal-gauge ... ... ... | 24,866. |
| Metre gauge ... ... | 2,287. |
| Light railways, 60 cm.... | 139,411 tons. |
| *Roads Mechanical Transport*— | |
| Total tonnage ... ... | 84,516. |
| Ton-miles ... ... | 359,327. |
| No. of lorries ... ... | 1,000. |
| *Quarries (worked by British)*— | |
| Marquese Group ... | 47,624 tons. |
| Other quarries ... ... | 19,448 tons. |
| *Personnel for Railways, Roads, Docks, etc.*— | |
| Skilled .... ... ... | 56,676 |
| Unskilled ... ... | 55,976 |
| Total ... ... | 112,652 |

The 352nd Electrical and Mechanical R.E. Company was established in December, 1916, and co-ordinated all the work for obtaining and receiving stores, installing, operating and repairs of all R.E. machinery in the Third Army area. It also dealt with water supply, electric lighting and workshops. This did not clash with the subsequently-formed R.E. Mechanical Workshops, which only did repetition manufacture. There were similar companies in the other armies.

A review of the workshop situation, especially in the early years of the war, leaves the impression that there should have been greater co-ordination between them. At one time a suggestion was made that a Corps of Mechanical Engineers should be formed, but whether separate from the R.E.'s or affiliated thereto was, I think, not specified. An organisation of this kind is, in my opinion, necessary to meet mechanical engineering requirements of war, but there are many difficult points to settle and many interests to be observed. In the event of such action being taken by the War Office, I am sure you will agree with me that this Institution should do all in its power to assist in the formation of any organisation that might be sought to be established, and, in particular, in keeping a register of its members as to their qualification for the various duties contemplated.

I now come to the work of the mechanical engineers at home. As regards how and when mechanical engineers were mobilised for war work at home, it is only necessary to record the fact that the Ministry of Munitions was formed in the first half of 1915, and under its control the various works in the country produced the munitions required of them, in addition to which the Ministry also constructed a large number of new works making shells, fuses, aeroplanes, sulphuric acid, nitric acid and explosives generally.

The control was exercised in various ways, but, broadly, the country was divided into areas, each administered by a committee. There were nine such areas, some of which were:—Metropolitan, Eastern Counties, Midlands, North-East Coast, Scotland, Birmingham and Ireland. In a general way it may be said that munitions included almost every industry carried on in peace time, in addition to the purely naval or military requirements that are associated with Woolwich Arsenal and the armament firms. Many works were extended and new works were built to manufacture articles of ordinary use, but required in enormously greater quantities for the conduct of the war, as well as extensions and new works needed for articles peculiar to warfare.

One of the areas referred to above may be taken as an example, namely, the Metropolitan area, and I consider this one because I was a member of its committee. The preliminary meeting took place in June, 1915, and a memorandum was prepared, which defined the work to be undertaken, and practically the committee undertook to supervise the work in the whole of the London area, but it was stipulated that it would in no way interfere with Woolwich or any of the firms already engaged in Government work.

Three sub-committees were appointed, viz., the management committee, the census committee, and the financial committee. The census committee was discontinued so soon as the various works had been selected. In this connection the total number of works inspected was 923, of which 355 were found suitable, and ultimately made munitions of various kinds to a greater or lesser extent. In addition to these existing works, new works were established, such as the projectile works at Staines, and a filling factory at Park Royal, which was of very considerable extent.

The first and most pressing difficulty was in connection with the production of gauges, which became so acute that a sub-committee was formed to deal with the matter. Dr. Unwin was chairman of this committee, and I would like here to record the value of the services he rendered on this occasion. At that time the outcry was for shells, and the work of the Metropolitan Committee was practically concentrated on shells and on fuses and gaines.

The following statistics will give some idea of the work actually done by the Metropolitan Committee during its existence from June, 1915, to June, 1918:—

Metropolitan Munitions Committee.

*Total Output of certain items at June 29, 1918.*

| | |
|---|---|
| *Shells* ... ... ... ... | 8,198,874 |
| Including— | |
| 18-pdr. high-explosive ... | 1,766,599 |
| 9·2 ,, ... ... | 128,659 |
| 6 in. ,, ... ... | 377,560 |
| 4·5 ,, ... ... | 1,322,744 |
| 18-pdr. shrapnel ... ... | 1,514,224 |
| 3 in. Stokes ... ... | 976,407 |
| Grenades ... ... ... | 798,449 |
| *Components* ... ... ... | 45,294,837 |
| Including— | |
| Gaines... ... ... ... | 8,240,788 |
| Adapters ... ... ... | 11,631,848 |
| Primers ... ... ... | 13,718,456 |
| *Sundries* ... ... ... ... | 87,487,740 |
| Gauges ... ... ... ... | 247,051 |
| Value of these articles and others not mentioned ... ... ... | £14,923,949 |

Early in 1917 a department called the Munitions Works Board was established, whose duties were to examine and criticise, authorise or otherwise, any scheme put forward by a manufacturer for enlarging his works and for installing machinery for the production of munitions, and a further duty was to see that the work so authorised was duly carried out. Such a department, although starting late, was obviously necessary because, owing to the shortage of materials, they had to be rationed in accordance with the importance of the work and only a centralised department could have the necessary information for such decisions. It is to be feared, however, that in many cases the time taken to obtain authority led to great delays and retarded supplies.

In 1915, in pursuance of the Defence of the Realm Act, powers were taken to control firms capable of producing munitions. Certain facilities were given to these firms to obtain labour and materials and as regards finance, although in many cases assistance was given by the Government, the capital required for extensions to buildings and plant was provided by the firms themselves. The assets thus created would obviously have very varying values when no longer required to make munitions and it was, therefore, provided that the firm should be reimbursed with that portion of this expenditure which represented the difference between the amount of the actual expenditure and the post-war value of the assets to the firm produced by this expenditure.

Strictly, the value could only be ascertained after the war, but to wait until an unknown date to fix an unknown value was not an inviting prospect to capitalists or manufacturers. The apparently impossible task of predicting this value was undertaken and, with a view

to inspiring confidence, an honorary advisory committee was formed to deal with the matter. The first step in the formation of this committee was taken by Mr. Basil Mott in December, 1915, and the late Mr. Chatfield Clarke and was ultimately composed of the following members :—

*Chairman ;* Mr. Seager Berry.

*Engineers ;* Mr. Basil Mott, C.B., Colonel Morgan, C.B.E., Captain Sankey, R.E. (ret.)

*Surveyors ;* Mr. Leslie Vigers, Mr. Jonas, C.B.E., Mr. Head. (The latter gentleman joined the committee on the death of Mr. Chatfield Clarke.)

Originally this committee was attached to the Ministry of Munitions and later was transferred to the Board of Inland Revenue. Throughout the committee has been in an independent advisory position, a position which it jealously guarded, for otherwise it was felt that it would not be able to gain or maintain the confidence of both the Government and the controlled firms.

The committee began its work in March of 1916, and has still a few cases to report upon. A set of rules was drawn up to regulate the method of ascertaining the residual or post-war value of the expenditure incurred and it was an invariable rule that every works should be visited, the smaller works by the staff and the larger by the members of the committee before any conclusion was arrived at. The chief of the staff was Colonel d'Alton, M.I.Mech.E., and I would like to take this opportunity of expressing my own personal appreciation, which I know is shared by the committee, of the excellent services he has rendered. He has helped me materially in getting information for this part of my address, and has enlisted the services of several of his friends.

The heads of the firms, recognising that the committee was not a body of Government officials, but were giving their services in an honorary capacity, supplied to the committee quite openly private information which greatly assisted in arriving at a true and fair value of the post-war assets, and there can be no doubt that this confidence quickened the faith of the manufacturers in their governmental employers, and by stimulating the patriotic energy which was so marked a characteristic of these manufacturers, helped to raise the output of munitions to the satisfactory pitch which it eventually attained. Tables illustrating the work of the committee are given below :—

*Abstract from the Records of Works Inspected by the Valuation Committee.*

| Kind of Munition. | Number of Towns in which the Works were situated. | Districts in which the greatest capital expenditure for extensions of works occurred. | Total Capital in expended extensions. |
|---|---|---|---|
| | | | £ |
| Shells .. .. | 76 | Yorkshire<br>Lancashire<br>Midlands<br>London | 8,500,000 |
| Explosives and poison gases. | 44 | Yorkshire<br>Lancashire<br>Cheshire<br>Scotland<br>Midlands | 7,880,000 |
| Guns and their mountings. | 47 | Midlands<br>Eastern | 950,000 |
| Aeroplanes, seaplanes, flying boats. | 31 | London<br>Midlands<br>Eastern | 1,130,000 |
| Aeroplane engines | 17 | Midlands<br>London district | 2,300,000 |
| Tanks and their components. | 17 | Midlands | 390,000 |
| Steel .. .. | 41 | Yorkshire<br>Wales<br>Scotland | 4,650,000 |

The above is only a small part of the capital expenditure on works extensions, as it does not include armament firms or national factories.

*Valuation Committee.*

I.—Number of companies whose establishments have been inspected by the committee or their staff :—

| | No. |
|---|---|
| (*a*) Spending more than 1,000,000*l.* on buildings and plant ... ... | 8 |
| (*b*) Spending between 500,000*l.* and 1,000,000*l.* ... ... ... ... | 12 |
| (*c*) Spending between 100,000*l.* and 500,000*l.* ... ... ... ... | 90 |
| (*d*) Spending between 20,000*l.* and 100,000*l.* ... ... ... ... | 319 |
| (*e*) Spending less than 20,000*l.* ... ... | 726 |
| Total ... ... ... ... | 1,155 |

II.—Locality. Number of controlled establishments dealt with in the following districts :—

| | No. |
|---|---|
| Scotland ... ... ... ... | 156 |
| Northern ... ... ... ... | 269 |
| Midland ... ... ... ... | 461 |
| Southern ... ... ... ... | 39 |
| Eastern ... ... ... ... | 39 |
| London ... ... ... ... | 160 |
| Ireland ... ... ... ... | 2 |
| Wales ... ... ... ... | 38 |
| Total ... ... ... ... | 1,155 |

III.—Total expenditure on plant considered by committee :—

| | £ |
|---|---|
| | 54,876,108 |
| Total expenditure on buildings considered by committee ... | 27,096,743 |
| Total ... ... ... | 81,972,851 |

The great variety of the production of the works valued by the committee will be realised from the following list :—

Pig iron—C.I. castings.
Steel ingots, forgings, stampings and castings.
Steel sections and bars.
Shell billets.
Copper ingots and all kinds of alloys.
Tungsten powder and ferro-tungsten.
Machine tools of all kinds—Hydraulic presses, steam hammers, cranes and travellers.
Metal sheets, tubes of steel and copper—all sizes. Wire rope and wire netting.
Boilers—steam engines (land and marine).
Oil and gas engines—gas producers.
Optical and scientific instruments.
Guns of all calibres, howitzers and bomb throwers—rifles, Lewis and machine guns.
Shells of all calibres and in all stages of manufacture, gaines, fuses and component parts.
Shell filling.
Mines, hand-grenades, bombs, torpedoes, cartridge cases.
Bayonets.
Explosives of all kinds—sulphur, nitric and other acids. Poison cases.
Chemicals—dyes.
Ships of all sizes, both naval and mercantile.
Motor vehicles and their component parts, such as chassis, engines, &c.
Tanks and their components.
Aircraft and their components, such as engines, fuselage, frame-work, fabrics.

The extensions made to works can be divided into three broad categories, as affecting post-war values, namely :—

(1) Merely an extension of the ordinary work of the firm, such as the making of machine tools in larger quantities and in larger sizes, hydraulic presses of the ordinary kind and of special kinds, motor lorries, tubes of many kinds. In such cases the expenditure incurred would be of post-war benefit to the company and hence to the country. On the other hand plant for largely increasing the making of glycerine at soap works or for enormous increase in small arm ammunition manufacture would have little post-war value.

(2) Work of a similar nature to pre-war work but so modified for war purposes as to be otherwise useless, such as, for example, special aeroplane engines, manufactured by makers of motor-car engines. Examples of this class are given in the following table :—

GROUP II.

SIMILAR PRODUCTION.

| War. | Pre-war. |
|---|---|
| Forgings for shell presses ... | Colliery winding engine forgings. |
| Steel for shell billets ... | Steel for tinplate billets. |
| Steel tubing for aircraft ... | Steel tubing. |
| Springs for guns ... ... | Springs for railways. |
| Machine gun belts ... ... | Penmakers. |
| Howitzer parts forgings ... | Crank-shaft forgings. |
| Filling hand grenades ... | Fireworks. |
| Trench howitzer bombs ... | Castings. |
| Smoke producing appliances | Fireworks. |
| Fuses... ... ... ... | General brass founders. |
| Fuses... ... ... ... | Gas, water and electric fittings. |
| Casting cartridge metal ... | Artistic metal work. |
| Repairing brass cartridge cases. | Brass stampings. |
| Castings for hand grenades... | Light castings for building trade. |
| Trench warfare munitions | Railway, ship and tramcar fittings. |
| Plant for explosives ... | Plant for chemical works. |
| Glycerine and explosives ... | Dyes and chemicals. |
| Cordite incorporating machines. | Baker's machinery. |
| Destroyers, submarines ... | Cross-channel steamers. |
| Pontoon wagons ... ... | Railway wagons. |
| Aeroplane engines ... ... | Motor-car engines. |

(3) Entirely different work to that carried out in peace time by the firm as shown below :—

GROUP III.

DISSIMILAR PRODUCTIONS.

| War. | Pre-war. |
|---|---|
| Guns ... ... ... | Motor cars. |
| Gun carriage details ... | Sluice valves and hydrants |
| Shells ... ... ... | Almost every kind of work. |
| 6-in. shells ... ... ... | House decoration. |
| 9·2-in. shells ... ... ... | Rubber making machinery |
| Fuse bodies ... ... ... | Electric cables. |
| Fuses and gaines ... ... | Motor cars. |
| Mines, fuses, hand grenades | Incandescent electric lamps. |
| Electric contact mines ... | Heating and ventilating. |
| Bomb heads and lathes ... | Domestic mangles. |
| Hand grenades ... ... | Machinery for preparation of food. |
| Howitzer bombs—mine sinkers. | Rubber making machinery. |
| Plant for explosive works... | Paper making machinery. |
| Explosives ... ... ... | Constructional steel. |
| Aeroplane parts ... ... | Textile machinery. |
| Aeroplane parts ... ... | Printers machinery. |
| Rotary aeroplane engines ... | Centrifugal pumps. |
| Marine engines ... ... | Dynamos. |

It is certain that most firms did not realise at first the difficulty of manufacturing munitions of war. Generally the materials used have to be of exceptional quality and are often difficult to machine, and the degree of accuracy needed is far greater than is usual. Taking shells as an example, the steel had to be of a special hard quality to resist the blow of the charge on firing. It was, therefore difficult to make in the first instance, except by armament firms, and until steel makers had obtained the necessary experience the outputs were low. After a time, however, the great demand for one particular steel leading to the constant running of the plant resulted in increased outputs. The cogging and rolling was also rendered more difficult, and much had to be learnt. Owing to want of skilled labour and deferred repairs, it was no easy matter to keep the plant running full bore.

It is interesting to point out that, owing to the assistance given by the Ministry to individual firms, this country is in a far better position than it was before the war as regards plant for steel making and for forging. Capital in the vicinity of 10 to 15 millions has been spent in forging plant, such as hydraulic presses, furnaces, gas producers, waste heat boilers and heat treatment plant, and the buildings.

Even the apparently simple process of breaking the rolled bars into billets gave much trouble, and unless special care and trouble was taken the billets did not break straight across, giving subsequently much trouble in piercing. The next stage—the piercing of the billet—was found to be a difficult operation. The piercer was apt to wander and much scrap was thus produced. The machining of the steel was quite different from what most workmen had been accustomed to. The hardening of the tools and the rate of cutting were outside the usual experience of the workmen. The tolerances were small because any shell had to fit accurately any gun of the same calibre. Added to this the weight had to be kept within very small limits to ensure accuracy in range.

The same sort of difficulties were encountered in the large majority of munitions required for artillery, and it is a matter for great congratulation that our manufacturers, both heads and workmen, rose to the occasion and produced work of the necessary quality and in the necessary quantity. I cannot help remarking that many of these troubles should never have existed and that consequently munitions in sufficient quantities would have been ready at an earlier date had more foresight been exercised so that arrangements would have been made for instruction in times of peace of certain selected firms and workmen in the making of such munitions of war. Further, an adequate stock of gauges should have been kept. It would be interesting to know what has become of all the gauges that were made, and whether they have been properly stored and identified for future use. A very serious cause of delay and unnecessary expense was due to the fact that the control of mechanical engineering operations was not placed in the hands of competent and experienced mechanical engineers but in that of men of other professions, whose training prevented them from realising the issue involved. In many cases the mechanical engineer had to educate his superior in office.

At first, for obvious reasons, makeshift had to be made with the machine tools available, then special attachments were applied, and as time went on many single purpose machines were brought into operation, especially in connection with shell making. Of the many makeshifts I have selected two. Ordinary power-driven planing machines were used for piercing shell billets. Many millions of shells were produced in this way. In the case of small calibre guns, the tubes and jackets were rolled instead of forged, thus relieving the forging presses and producing equally good results.

Great ingenuity was displayed in the design of jigs and fixtures, and many special machines were designed to meet the conditions of rapid and accurate manufacture of shells, for instance, or their component parts.

Special vertical hydraulic presses were employed for piercing the blanks for shells by the Erard process. These presses are of quite special dimensions, i.e., the columns are very close together in relation to the power of the press. They are, therefore, not at all suited for general work and were regarded as of scrap value for post-war purposes.

The enormous number of the same thing that had to be made, combined with the accuracy required, imposed what are called "methods of interchangeability" and "mass production," and it cannot be doubted that many works have found out by practical experience the advantages of such methods as regards cost of production. It would be interesting to speculate on the effect of the war work on the methods of production, but time does not permit. It may, however, be said broadly that many firms in this country have learned to appreciate the difficulties and the advantages of the use of gauges, jigs and templates, standardisation and interchangeable manufacture of parts.

Although we have had a British Standards Association for many years, it may be doubted if the true meaning of standardisation was perfectly understood by those responsible for the conduct of many engineering firms in this country, although such methods had been adopted long ago for the manufacture of sewing machines, rifles and the Williams engine. The necessity of the war has been a great teacher in this matter and this is a legacy for which we ought to be thankful, and it is much to be hoped that the lesson thus taught will not be forgotten. It is believed that many firms who, before undertaking shell work had no definite limit system, have now adopted such and are finding great benefits therefrom.

One of the important matters entrusted to the Valuation Committee was to settle what increase in deprecia-

# DETAILS OF 2-10-0-TYPE LOCOMOTIVE; PENNSYLVANIA RAILROAD.

CONSTRUCTED TO THE DESIGNS OF MR. J. T. WALLIS, CHIEF OF MOTIVE POWER, PHILADELPHIA, PA., U.S.A.

(For Description, see opposite Page.)

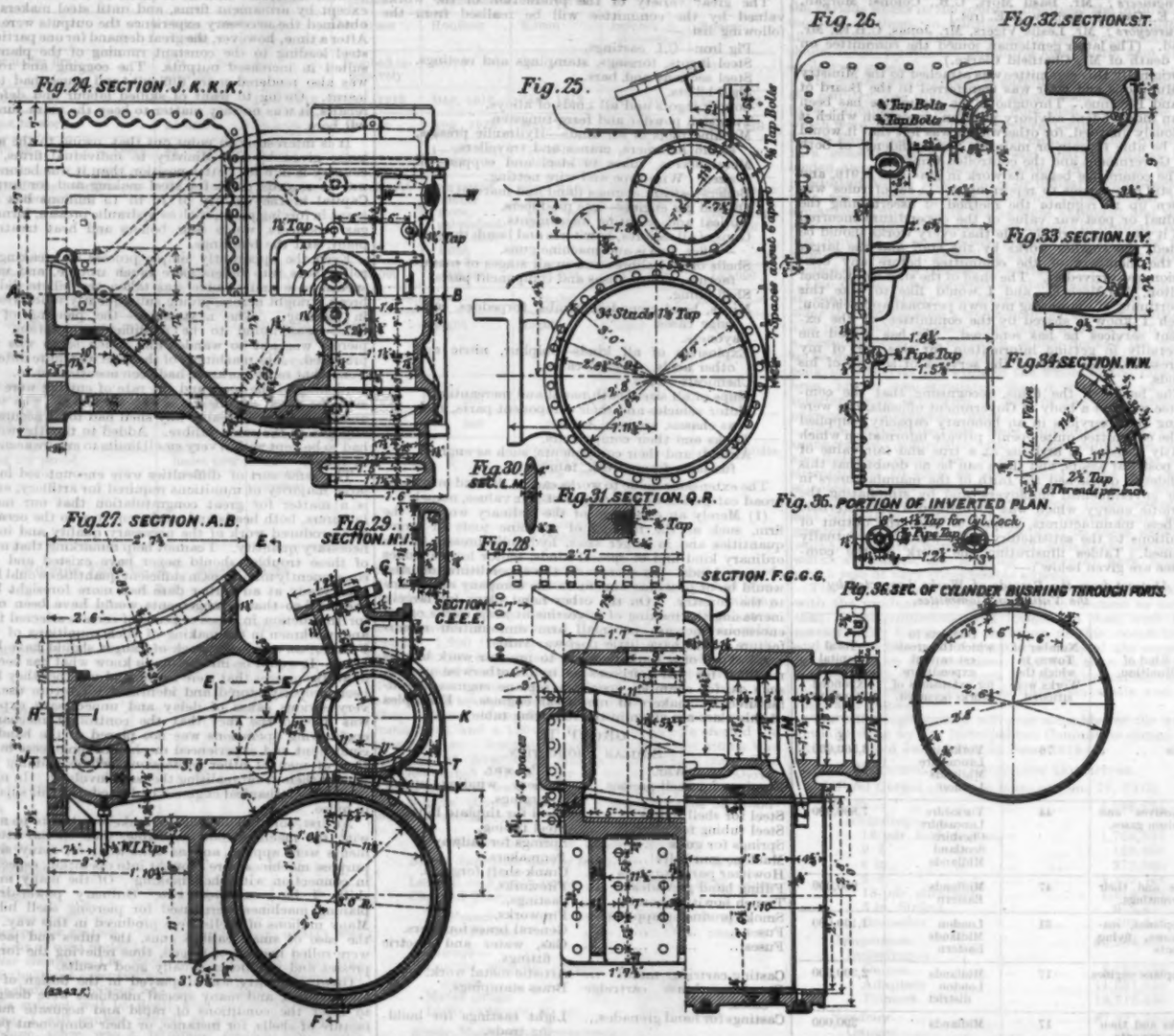


Fig. 24. SECTION J. K. K. K.
Fig. 25.
Fig. 26.
Fig. 32. SECTION S. T.
Fig. 33. SECTION U. V.
Fig. 34. SECTION W. W.
Fig. 27. SECTION A. B.
Fig. 29. SECTION N. I.
Fig. 30. SECTION L. M.
Fig. 31. SECTION Q. R.
Fig. 28.
SECTION F. G. G. G.
SECTION C. E. E. E.
Fig. 35. PORTION OF INVERTED PLAN.
Fig. 36. SEC. OF CYLINDER BUSHING THROUGH PORTS.

tion of plant and machine tools should be allowed in order to take account of the effect of war conditions. For this purpose visits were made to several machine tool works and a recommendation was made, which was subsequently embodied in the regulations. The depreciation was increased for several reasons, such as the employment of unskilled labour, and longer hours the machine tools were at work, the constancy of the operation carried out by any particular tool, resulting in local wear, as, for example, in the bed of a lathe.

So far my remarks in connection with the Valuation Committee have had reference to plant only, but the buildings erected to accommodate the extensions of plant had also to be examined to determine their post-war value to the owner. Many of these buildings were temporary structures, but a large number were of more or less permanent character, and ought to find useful application in various directions. Aeroplane construction required very large shops with an unusual amount of free space. This required roofs of large span from 80 ft. to 100 ft., which added to the cost of such buildings, without increasing the post-war value.

The welfare of the workers was a matter which was early taken into consideration, and the matter was administered by the welfare department established by the Ministry of Munitions, which did its best to assist in order that the comfort of the workers might be improved. The actual carrying out of the work, i.e., the provision of the necessary buildings, the appliances and the running of the canteens was done by the respective firms.

The common cause and the facing together of danger by all ranks of society gave many the hope that after the war better relations would exist between masters and men, employers and employees, but from the present outlook it is obvious that such a hope is not to be fulfilled at present; in fact the gulf is wider than ever. It may be that the long duration of the war obliterated these good influences and that they have been replaced by malign influences. Cannot we hope, however, that the good seed sown in the early days of the war may yet germinate and eventually lead to the desired end, so that with the improved methods of manufacture and the better machinery now available, with good-will, mutual confidence and team work of all ranks in the works an era of prosperity may shortly dawn in this country?

This leads to the consideration of the human element in industry, and I wish to call attention to the paper on the subject read by Mr. Ramsay at the Lincoln Summer Meeting. Hitherto this institution has refrained from dealing with subjects other than of technical interest, except a paper by Miss Ashworth on "The Employment of Women during the War," and a paper by H. H. Morgan, on "The Efficient Utilisation of Labour in Engineering Factories." In my view the innovation is most desirable, and I feel that the institution has a great field of usefulness in this respect, but inasmuch as the Council has decided that a special meeting is to be held in London on December 3, to be followed, it may be hoped, by local meetings, to discuss Mr. Ramsey's paper I will refrain from further remarks, only urging the importance of the subject.

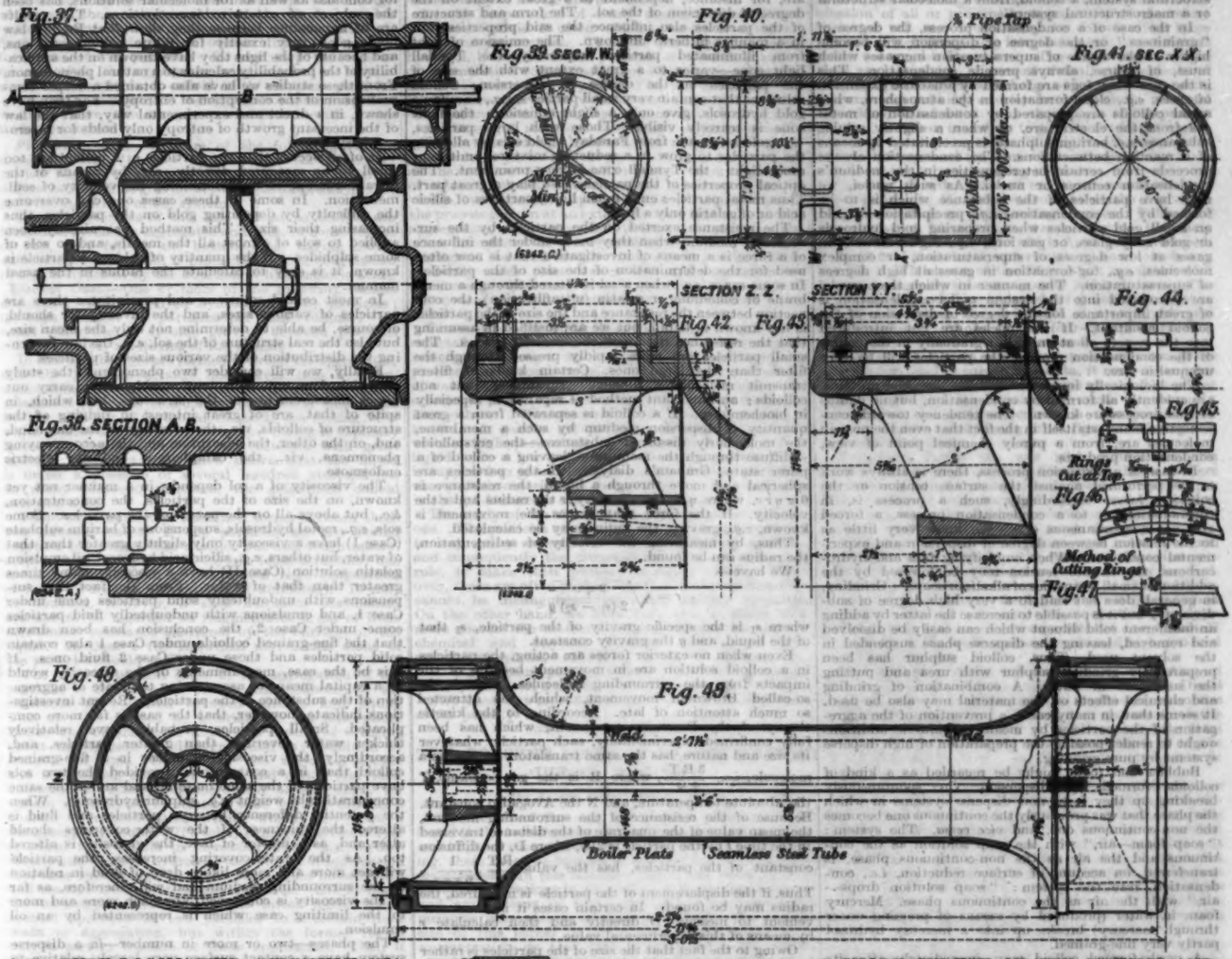
I feel that what I have said describes very inadequately the work done by mechanical engineers during the war, but I hope that I have been able to show that the services they were capable of rendering were not recognised by the authorities until the end of the second year of the war. The mechanical engineers are not altogether free from blame in this matter because they have not asserted themselves sufficiently and have not let the public know what their capabilities are. In my opinion this Institution should bestir itself to correct this state of things. To read and discuss papers, and to promote various social functions, such as summer meetings, annual dinners and conversaziones should not constitute the whole of its activities. I look forward to the time when this Institution will render far more useful services to the community and, together with its sister Institutions will consider seriously the ways and means of showing to the public that modern civilisation is entirely dependent on engineering, using the term in its broadest sense.

---

Electrolytic Corrosion of Lead.—The question of using hard and soft lead in stills and coils was raised some years ago by Eckelt who reported a case of an ether still (in which a mixture of sulphuric acid and alcohol was distilled) which had been destroyed in three days. In the *Chemiker Zeitung* of October 5 Dr. Oscar Schaal mentions that he had observed very bad corrosion of a similar still in seven hours and, in another instance, in thirteen hours. The coils were made of hard lead, the stills of soft lead, and the corrosion was, in the one case, noticed in the lower part of the still where the still bottom was soldered to an outer lead shell. When soft and hard lead are in contact, the soft pure lead becomes the anode and is attacked. Schaal measured currents of 0·2 ampere, and he ascribes the trouble to electrolytic corrosion. The corrosion can be obviated by careful earthing, but the electrolytic danger is frequently disregarded, and insufficient attention paid to earthing. In the cases in point the lead was found to be almost free of antimony, but to contain 0·85 per cent. of tin; it was a war-time installation. The lead used for such apparatus should be all uniform, and the parts should be separately earthed.

# DETAILS OF 2-10-0-TYPE LOCOMOTIVE; PENNSYLVANIA RAILROAD.

CONSTRUCTED TO THE DESIGNS OF MR. J. T. WALLIS, CHIEF OF MOTIVE POWER, PHILADELPHIA, PA., U.S.A.



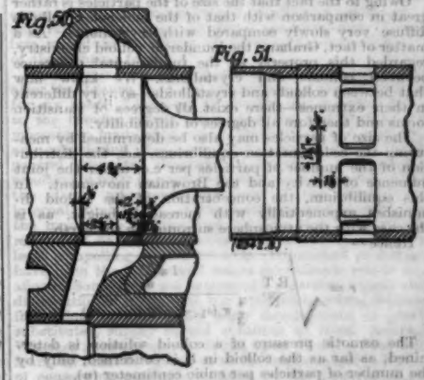

## 2-10-0-TYPE LOCOMOTIVE; PENNSYLVANIA RAILROAD.

(*Concluded from page 539.*)

THE most important departure in the design of this engine is connected with the use of the steam in the cylinders. Previous engines in the service for which this engine is designed were found to work for a very large percentage of their time at full gear. With the object of producing an engine which could work at a more economical cut-off, the cylinders were enlarged and the cut-off so arranged that the maximum cut-off is about 50 per cent. of the stroke. The arrangement appears to have worked out well, and the present engine at this cut-off gives a turning moment diagram much the same as that from the earlier engines at full cut-off. In order to obtain a sufficient starting effort auxilliary ports are fitted which allow steam to enter the cylinder, before the main ports are uncovered.

The cylinders are shown in Figs. 34 to 36, on page 584. They have inside admission, and are 30½ in. by 32 in. stroke. They are bushed. The pistons are conical and consist of a rolled steel centre with a cast-iron bull ring riveted to it. The piston rods are hollow, without tail pieces. The valves are of the piston type, and are shown in Figs. 37 to 51, annexed. The body is of the standard three-piece construction, adopted on this railway, consisting of a body and two end pieces enclosing anchor-rings and packing. The valves are 12 in. in diameter and weigh 147 lb., or with stems, &c., 219 lb. each. They have a travel of 6 in., and in order to secure a short cut-off with this travel 2-in. lap had to be provided. The lead in full gear is $\frac{1}{16}$ in. and the exhaust lap ¼ in.

The main ports are 2½ in. wide and each has an area of 76½ sq. in.; the auxiliary ports shown in Figs. 37, 50, and 51, above, are placed 1¼ in. inside the main ports. Each consists of a slot 1¼ in. long by ½ in. wide




placed across the bushing, and the valve lap for these ports is ¼ in. The valve bushings are shown in Figs. 39 to 41 and 51, on the present page. They are independent for each end of the steam chest and the wearing portion is ¾ in. thick.

The action of the auxiliary ports shows on indicator cards as an unusual preadmission of steam. It does not appear however, that the quantity admitted prolongs the admission period unduly after cut-off, and good expansion is secured. The valve motion is modified Walschaert gear.

The large size of cylinders and high boiler pressure produce a very high thrust on the crank pins, which are of the unusual size of 10 in. in diameter by 8½ in. in length, while the side rod main bearings are 11 in. in diameter and 6½ in. in length.

## A SHORT SURVEY OF THE PHYSICS AND CHEMISTRY OF COLLOIDS.*

By Dr. THE SVEDBERG, Professor of Physical Chemistry, University of Upsala.

THE science of colloids is a science of the microstructure of matter. In it is reflected the tendency of modern natural science to deal more and more intensely with the problem of structure in its full extent. In the great science of the structure of matter, the science of colloids forms the domain that lies above molecular dimensions and beneath microscopic dimensions. In this domain we have a great number of those systems which are the basis of our material culture and the basis of life as a whole. All living beings are built up of colloids; almost all our food, our articles of clothing, our building materials, are colloids. Or, to mention some special systems, protoplasm, proteins, glue, starch, all kinds of fibres, wood, brick, mortar, cement, certain kinds of glass, rubber, celluloid, &c. The importance of colloid science for many industrial questions is, therefore, beyond all doubt.

The science of colloids is a rather young one. The field of study which it concerns has for a long time been disregarded. In order to be able to treat with success all the questions presented to us by industry, there is still much to be carried out in the department of pure colloid science. In what follows, I will try to give a short review of the scientific results so far obtained and of the problems which, in my opinion, need especial attention.

The various branches of colloid science are connected to such an extent that it is very difficult to treat the different questions separately. We will try to fix our attention on two principal problems: (1) the formation of colloids, and (2) the changes of structure in colloid systems. Connected with both these is the problem

* Introductory Address (abridged) to the general discussion on "The Physics and Chemistry of Colloids and their Bearing on Industrial Questions," delivered before the Faraday Society and the Physical Society of London, October 25.

of the properties of colloids and the changes in these properties during the processes mentioned under (2).

The formation of a colloid may be effected in two ways, different in principle, viz., by condensation and by dispersion, according as one tries to obtain a micro-structural system, a colloid, from a molecular structural or a macrostructural system.

In the case of a condensation process, the degree of "graininess" or the degree of dispersion will become higher as the degree of supersaturation increases which must, of course, always precede condensation. This is the case when fogs are formed by adiabatic expansion of gases, *e.g.*, cloud-formation in the atmosphere, when metal colloids are prepared by condensation of metal gas from the electric arc, or when a slightly soluble substance, *e.g.* barium sulphate, is precipitated by means of a reaction between ions. The condensation always proceeds from certain heterogeneities in the medium's condensation centres or nuclei. As such nuclei, we may have particles of the substance which is to be formed by the condensation, *e.g.*, precipitation of gold on small gold particles when preparing gold hydrosols or gold ruby glass, or gas ions, *e.g.*, fog-formations in gases at low degrees of supersaturation, or complex molecules, *e.g.*, fog-formation in gases at high degrees of supersaturation. The manner in which these nuclei are introduced into the system under condensation is of great importance for the degree of dispersion of the colloid resultant. If the nuclei are not introduced into the system all at once, but gradually in the course of the condensation process, the particles will be very unequal in size.

The biologically important colloids, *e.g.*, the proteins, are evidently all formed by condensation, but no details of this process are known. The tendency towards condensation manifests itself in the fact that even the protein molecules are, from a purely chemical point of view, condensation products.

In case of a dispersion process, there is always work to be performed against the surface tension or the cohesion force. Accordingly, such a process is, in contradistinction to a condensation process, a forced and not a spontaneous one. We know very little as to the relation between degree of dispersion and experimental conditions. When emulsifying fats and hydrocarbons, the surface tension may be lowered by the addition of small quantities of alkalis or soaps. Grinding, in general, does not lead to a very high degree of subdivision; but it is possible to increase the latter by adding an indifferent solid diluent which can easily be dissolved and removed, leaving the disperse phase suspended in the solvent used. Thus, colloid sulphur has been prepared by grinding sulphur with urea and putting the substance in water. A combination of grinding and chemical effects on the material may also be used. It seems that, in many cases, a prevention of the aggregation of the particles by means of suitable additions ought to render possible the preparation of high disperse systems by pure grinding.

Bubbles and foam might be regarded as a kind of colloids formed by dispersion. On spontaneously breaking up they form new disperse systems in which the phase that was previously the continuous one becomes the non-continuous one, and *vice versa*. The system: "soap foam—air," with the soap solution as the continuous and the air as the non-continuous phase, is transferred, on account of surface reduction, *i.e.*, condensation, into the system: "soap solution drops—air," with the air as the continuous phase. Mercury foam in water (produced by means of pressing water through mercury) breaks up into a mercury hydrosol partly very fine-grained.

A newly-formed colloid may, immediately after its formation, undergo changes of structure of a more or less profound nature. On the other hand, it is nearly always possible to prevent the occurrence of such changes, and therefore we have a right to distinguish and investigate the primary structure as the direct result of the colloid-forming process. Colloids with primary structure may conveniently be called primary colloids.

We have at our disposal several methods for the closer study of the structure. Almost every property of a colloid depends on the structure, and therefore, conversely, from the study of the properties of colloids we may draw conclusions as to their structure.

The most important and most obvious means is the microscope and the ultramicroscope. With their aid, it is often possible to settle whether the colloid under investigation is of a grainy structure, *e.g.*, a colloid gold solution in water, a gold hydrosol, or of a foamy structure, *e.g.*, high disperse soap foam, or of a fibrous structure, *e.g.*, soap solutions of a certain concentration. The number and approximate size of the discontinuities, *e.g.*, the particles, may also be determined in this way. One may, for instance, count in the ultramicroscope the number of particles observed in a certain volume of gold hydrosol, and by means of analysis determine the content of gold present in the sol. From these figures we get the mass and approximate size if, for instance, we make the assumption that they are spherical. On the other hand, the ultramicroscope gives little or no information about the form or structure of the particles.

A means of deciding whether the particles are symmetrical is to be found in the study of the behaviour of the colloids in magnetic or electric fields. Non-symmetrical particles are oriented by such fields and thereby impart to the colloid a certain, though in general very slight, degree of double refraction, which may easily be measured with great accuracy. In this way, we have been able to settle that the particles in common sulphur hydrosols, prepared by oxidation of hydrogen sulphide, are spherical; but sulphur hydrosols, prepared by grinding sulphur with urea, are disymmetrical. The particles in gold hydrosols prepared by reduction are disymmetrical to a high degree.

Two other optical properties, viz., the light absorption and its accompanying phenomena, the scattering and polarisation of light—the Tyndall phenomenon—may also in certain cases be used for structure studies. Theory, as well as practice, proves that these phenomena are, for instance, dependent to a great extent on the degree of dispersion of the sol. The form and structure of the particles also influence the said properties, but in a manner hitherto unknown. The emission of light from illuminated particles especially—the Tyndall light cone—varies to a great extent with the size of the particles or the degree of dispersion. Colloid solutions that contain very small particles, *e.g.*, Faraday's gold hydrosols, give only a slight emission; the light cone is scarcely visible. Those with large particles, *e.g.*, gold sols made from Faraday's gold sols by allowing the particles to grow in a reduction-mixture, emit very much light; the Tyndall cone is very prominent. The optical properties of the particles also play a great part. Thus metal particles emit much light, particles of silicic acid or of gelatin only a little.

The resistance exerted on the particles by the surrounding medium when they move under the influence of a force is a means of investigation that is now often used for the determination of the size of the particles. In some cases, *e.g.*, when a sol is filtered through a membrane of collodium or gelatin (ultrafiltration), the connection between the resistance and the size of the particles is not known in detail, but we are justified in assuming that the resistance rises with the size of particles. The small particles are more rapidly pressed through the filter than the large ones. Certain kinds of filters transmit molecularly dissolved substances, but not colloids; an important method of separation, especially in biochemistry. If a colloid is separated from a great quantity of dispersion medium by such a membrane, the molecularly dissolved substances—the crystalloids—diffuse through the membrane, leaving a colloid of a purer state—Graham's dialysis. If the particles are spherical and move through a liquid, the resistance is $6\pi\eta r v$, where $\eta$ is the viscosity, $r$ the radius and $v$ the velocity. If the force that causes the movement is known, *e.g.*, gravity, the radius may be calculated.

Thus, by measuring the velocity of sedimentation, the radius can be found.

We have—

$$r = \sqrt{\frac{9\,\eta\,v}{2\,(s_1 - s_2)\,g}}$$

where $s_1$ is the specific gravity of the particle, $s_2$ that of the liquid, and $g$ the gravity constant.

Even when no exterior forces are acting, the particles in a colloid solution are in movement because of the impacts from the surrounding molecules. This is the so-called Brownian movement, which has attracted so much attention of late. According to the kinetic theory of the Brownian movement, which has been fully confirmed experimentally, each particle, whatever its size and nature, has the same translatory energy as a molecule, *i.e.*, $\frac{3RT}{2N}$, where R is the gas constant, T the absolute temperature, and N the Avogadro constant. Because of the resistance of the surrounding medium, the mean value of the quadrate of the distance traversed in the time $t$ by the particle is $2Dt$, where D, the diffusion constant of the particles, has the value $\frac{RT}{N} \cdot \frac{1}{6\pi\eta r}$.

Thus, if the displacement of the particle is measured, the radius may be found. In certain cases it is more convenient to measure D directly and then calculate $r$ by means of this experimental value.

Owing to the fact that the size of the particles is rather great in comparison with that of the molecules, colloids diffuse very slowly compared with crystalloids. As a matter of fact, Graham, the founder of colloid chemistry, regarded this property as the fundamental difference between colloids and crystalloids. We know now that between colloids and crystalloids—so very different in their extremes—there exist all degrees of transition forms and therefore all degrees of diffusibility.

The size of particles may also be determined by measuring the sedimentation equilibrium, *i.e.*, the distribution of the number of particles per c.c. under the joint influence of gravity and the Brownian movement. In this equilibrium, the concentration of the colloid diminishes exponentially with increasing height, as is the case with the atmosphere surrounding the earth.

Hence—

$$r = \sqrt{\frac{RT}{N} \cdot \frac{l\,n\frac{n_1}{n_2}}{\frac{4}{3}\pi\,(s_1 - s_2)\,g\,(x_2 - x_1)}}.$$

The osmotic pressure of a colloid solution is determined, as far as the colloid in it is concerned, only by the number of particles per cubic centimeter ($n$).

We have—

$$p = \frac{RT}{N} \cdot n$$

Consequently, the osmotic pressure is a measure of the degree of dispersion. The osmotic pressure of a colloid is often determined by means of a common osmometer, provided with a membrane permeable to crystalloids, but impermeable to the colloid particles. Now, however, owing to ion absorption, the particles are, in most cases, surrounded by an electric double-layer of ions, and the colloid thus acts as an electrolyte, one ion of which is able to penetrate the membrane, but not the other. This causes complications. A so-called membrane equilibrium is formed, and the osmotic pressure found is not a real measure of the structure of the colloid.

Owing to the Brownian movement, the number of particles in every small volume of a sol undergoes spontaneous and incessant fluctuations. Hence the value of every property of the colloid in the small volume fluctuates.

This phenomenon, predicted by the kinetic theory for colloidal as well as for molecular solutions, has been the subject of extensive investigations. The results are of importance because they show that Boyle's law holds good very exactly for dilute colloid solutions, and because of the light they have thrown on the applicability of the probability calculus to a natural phenomenon. From these studies we have also obtained a deeper comprehension of the conception of entropy. For they have shown, in a direct and experimental way, that the law of the incessant growth of entropy only holds for macroscopic systems.

It often occurs that the particles of a colloid are too small to be measured directly, *e.g.*, by means of the ultramicroscope or by determining the velocity of sedimentation. In some of these cases one can overcome the difficulty by depositing gold on the particles, thus increasing their size. This method has already been applied to sols of almost all the metals, and to sols of some sulphides. If the quantity of gold on a particle is known, it is easy to calculate the radius in the usual manner.

In most colloid solutions and precipitates there are particles of various sizes, and the investigator should, of course, be able to determine not only the mean size, but also the real structure of the sol, *e.g.*, the law governing the distribution of the various sizes of particles.

Finally, we will consider two phenomena, the study of which does not, it is true, enable us to carry out direct measurements of the structure, but which, in spite of that, are of great interest in judging of the structure of colloids, viz., the viscosity on the one hand, and, on the other, the adsorption and the accompanying phenomena, viz., the cataphoresis and the electric endosmose.

The viscosity of a sol depends, in a manner not yet known, on the size of the particles, the concentration, &c., but above all on the nature of the particles. Some sols, *e.g.*, metal hydrosols, suspensions of barium sulphate (Case I) have a viscosity only slightly greater than that of water, but others, *e.g.*, silicic acid hydrosol, oil emulsion gelatin solution (Case II) have a viscosity many times greater than that of water. From the fact that suspensions with undoubtedly solid particles come under Case 1, and emulsions with undoubtedly fluid particles come under Case 2, the conclusion has been drawn that the fine-grained colloids under Case 1 also contain solid particles and those under Case 2 fluid ones. If this be the case, measurements of the viscosity would be a capital means of ascertaining the state of aggregation of the substance of the particles. Recent investigations indicate, however, that the case is far more complicated. Small particles probably have relatively thicker water coverings than greater particles, and, accordingly, the viscosity is higher in a fine-grained colloid than in a coarser one, provided the two sols have particles of the same material and are of the same concentration by weight (*e.g.*, sulphur hydrosols). When the potential difference between particles and fluid is altered the thickness of the water-coverings should alter and, as a matter of fact, the viscosity is altered too. As the water-covering increases, the particle will act more and more like a drop of fluid in relation to the surrounding medium and will, therefore, as far as the viscosity is concerned, approach more and more to the limiting case which is represented by an oil emulsion.

The phases—two or more in number—in a disperse system have a contact surface very largely relative to the volume of the system. It is obvious that in such circumstances adsorption differs in strength. If an electrolytically-dissociated salt is adsorbed, cations and anions are, of course, brought together at the contact surface in equal numbers, but the adsorption of the particles in relation to cations and anions is most often unequal, inasmuch as one is present in excess nearest to the surface of contact and the other in excess some way out of the liquid. The result is the formation of an electrical potential difference, a so-called adsorption potential difference or an electrical double-layer. Because of this the disperse phase, when exposed to the influence of an electric field, will migrate towards one of the poles, provided it is freely movable, as in the case of a colloid solution (cataphoresis). If the disperse phase is immovable the liquid will move in the opposite direction (electrical endosmose). By measuring the velocity of migration of the particles or the liquid under various conditions we are able to study the changes in the difference of potential and thereby in the adsorption. At least at low concentrations the adsorption may be expressed by the formula—

$$y = a \cdot c^{\beta}$$

where $y$ is the amount of substance adsorbed per grain adsorbent, $c$ the concentration in the solution of the substance adsorbed, and $a$ and $\beta$ constants depending on the nature of both. Now, as a rule, it happens that for the two ions of a salt both $a$ and $\beta$ have different values, *e.g.*—

$a$ cation $< a$ anion

$\beta$ cation $> \beta$ anion

In the example chosen the disperse phase will with increasing adsorption become more and more negative in relation to the dispersion medium. This charge reaches a maximum and decreases to zero, at the point where the adsorption isotherms intersect, then becomes positive and increases again.

The changes of state which may occur in a disperse system, a colloid, are essentially changes of structure. Of course, purely chemical reactions, too, are to be taken into consideration, but they do not play such a prominent

part here as in the molecular structural systems. The greater number of the disperse systems, and those of greatest importance too, are the ones whose disperse phase is embedded in the other phase in the form of particles; in the sequel we will only mention the changes of state in such systems. The most important change of state is the uniting together of the single particles (primary particles) into aggregates (secondary particles). Such an aggregation often occurs directly after the formation of the particles. It may stop for various reasons after the aggregates have reached a certain size. The result is a colloid with complex particles —a secondary colloid. If the aggregation goes on further we may have two extreme possibilities—with many transition forms.

*First Case.*—On or more of the following factors dominate, viz., (1) Low hydration of the particles; (2) low number of particles per unit volume; (3) great difference in specific gravity between particles and liquid; (4) violent stirring of the system.

The characteristic of this case is that no bridges are formed between the aggregates and that, in consequence of this, they fall to the bottom after having grown sufficiently; the colloid is precipitated (*e.g.*, coagulation of a gold hydrosol by the addition of hydrochloric acid).

*Second Case.*—One or more of the following factors dominate, viz.: (1) High hydration of the particles; (2) high number of particles per unit volume; (3) small difference in specific gravity between particles and liquid; (4) no stirring of the system.

In this case bridges are formed between the aggregates, and the particles arrange themselves into a three-dimensional network throughout the system: the colloid gelatinises (*e.g.*, the coagulation of a sol of silicic acid by the addition of hydrochloric acid, the setting of a warm gelatin solution when cooling). Owing to capillary forces the liquid is kept in the network with great strength. Measurements have shown that the liquid is under a pressure of several hundred atmospheres. In many respects, therefore, the gelatinised colloid acts as a solid.

There exist numerous transition forms between these two extreme cases. If the particles are not bound together by bridges into a solid, but still reach micro-scopical size and possess a certain loose structure, one speaks of flocculation of the colloid (*e.g.*, coagulation of ferric hydroxide by addition of ammonia). It may be doubted, however, if such flocculent suspensions are not to be regarded as fragments of a gel of little mechanical resistance shattered by the stirring of the liquid. In Case 1 the Brownian movements alone of the particles should suffice.

The most important cause of the aggregation of the particles is the decrease or the disappearance of the difference of potential between particle and liquid. This may be effected by altering the ion adsorption. Hence one of the most important means of bringing about aggregation or disaggregation is: addition or removal of ions. Because of the opposite electric and coagulating action of anion and cation and their difference of adsorption there will always exist, for certain electrolytes in relation to a certain colloid, a domain of concentration within which they have a disaggregating action. If a solely aggregating electrolyte is added to a colloid in increasing doses (*e.g.*, hydro-chloric acid to a gold hydrosol), the velocity of aggregation first rises rapidly with concentration, then more slowly and reaches a constant maximum value. Let us make the assumption that within the latter region every mutual approach of two particles to a certain limit leads to aggregation, but within the former region only a certain fraction of those approaches. Then it is possible to develop, on the basis of the laws of the Brownian movements alone, a mathematical theory for the kinetic of aggregation.

With regard to the aggregation by electrolytes it has, in addition, been found that inorganic ions of the same valency generally aggregate equally strongly if added in equivalent amounts. This is due to some extent to their being nearly equally strongly adsorbed. When the valency of the aggregating ion increases, the aggregating effect rises very rapidly. The concentrations of the ions K· Ba ·· Al ··· required to aggregate particles of $As_2S_3$ to the same degree show the mutual relations: 1, 1/20, 1/1,000. Thus the three-valent Al ··· has an aggregating power 1,000 times greater than the mono-valent K·. These circumstances are closely related to the course of the adsorption isotherm, but are not yet quite clear.

The aggregation may be reversible or irreversible, *i.e.*, in certain cases disaggregation may be effected, in others not. Some colloids (*e.g.*, metal hydrosols) are difficult to disaggregate, others (*e.g.*, sulphur hydrosols) are easy. Certain ions nearly always bring about irreversible, others reversible aggregation. The question of irreversible or reversible coagulation is probably closely connected with that of the hydration of the particles. Thus particles which hold much water around them are easily disaggregated. The water-covering prevents the particles from uniting too closely together.

The aggregating effect of an electrolyte may often be reduced to a very great extent by the addition of a small quantity of a suitable colloid of another kind only slightly sensitive to electrolytes, a so-called pro-tective colloid, *e.g.*, gelatin to a gold hydrosol. As a rule the electric charge of the protective colloid should be of the same sign as that of the colloid to be protected. The mechanism of this protecting action is still but very incompletely known. Most probably the particles of the protective colloid become attached to the particles of the other colloid and the aggregate resulting from this obtains a good deal of the stability towards electrolyte which characterises the protective colloid. Colloids of opposite electric charge precipitate each other mutually (*e.g.*, the negative $Sb_2S_3$ and the positive $Fe_2O_3$) provided there is not too great an excess of either of them, in which case no precipitation will occur. This is obviously entirely analogous to the action of the ions. Such mutual colloidal reactions are of great importance in the economy of nature and in industry.

In the preparation of easily aggregated colloids a protective colloid is often added in order to maintain the primary structure. Thus the particles of a metal hydrosol, if formed in the presence of a small quantity of a protective colloid, are kept apart even when the sol is evaporated to dryness. The dry substance can be redissolved in water without any perceptible change of structure taking place (*e.g.*, commercial colloid silver).

A change of structure that plays a part, formerly a little over-rated, in colloid solutions with comparatively easily soluble particles is the growth of the larger particles at the expense of the smaller ones. In a suspension of calcium sulphate this change of structure is clearly visible, but in the more sparingly soluble barium sulphate the process goes on at an extremely slow rate. Formerly, aggregation, especially the irreversible process, was often interpreted as a recrystallisation. In irreversible aggregates as well as in compressed powders there gradually take place association and crystallisation phenomena which may greatly change the structure of the system (*e.g.*, silver crystals in sediments from silver colloids).

Processes of the latter kind play a prominent part, especially in gelatinised colloids. On the whole, a great variety of changes in structure and accompanying processes may occur in gels. When gradually deprived of water the gel of silicic acid, for instance, goes through a series of states, some of which differ rather decidedly from others. The nature of these processes is not yet known. A gelatin gel probably consists of particles with a high percentage of "dry substance," and a liquid with a low percentage. In sol-formation water is supposed to pass over from the liquid to the particles, the particle-associations being thereby disintegrated; in the gel-formation the particles lose water.

The study of the structure of gels is a rather difficult one. The particles of most gels do not contrast optically to any great extent with the surrounding medium, and consequently the ultramicroscope is not able, as a rule, to make their primary particles visible. More-over, these are often packed together so closely that they cannot be distinguished from one another optically. On the other hand, we have been able to study with more success the macroscopic properties of the gels in chemical and physical respects. The elastic gels, especially gelatin, collodion, celluloid, rubber, &c., play a prominent part in industry, and their investiga-tion is, therefore, a matter of great importance.

(We have not reproduced the 57 literature references of the paper.]

## THE PRESENT POSITION OF THE MARINE DIESEL ENGINE.*

By James Richardson, B.Sc.]

As a result of the war, considerable gaps are to be found in the technical progress of many peaceful pursuits, and in those cases that apply to British marine engineer-ing, these must be bridged if our position is to be fully maintained. In this country, during the years 1914 to 1918, considerations in connection with the development and applications of the Diesel engine for mercantile purposes were almost completely shelved. The exigen-cies of this period of stress and danger necessitated concentration on that type of machinery—the triple-expansion steam engine—most capable of being easily and rapidly produced by those manufacturing plants less suited to the duty of meeting the requirements of the fighting forces.

In reopening the subject of the marine Diesel engine, after its absence from the proceedings of the Institution for six years, I propose to confine my remarks solely to the broader issues, in view of the fact that at the moment so many shipowners, shipbuilders and engineers are considering this new prime mover chiefly in its general aspects. Conditions operating at present, resulting in large measure from the war, make most potent the claims advanced in favour of the principle of internal combustion. Quite suddenly and recently for the mercantile marine, fuel oil has been very widely recognised as the most suitable combustible. Not the least compelling factors towards this marked preference have been the labour and wages movements ashore and afloat. Some fears are entertained regarding supply and distribution of liquid fuel, but with transporting tonnage increasing and the likely early development of petrol substitutes, supply should continue to equal demand. Whether grounds may be found upon which to base such fears, all must be agreed as to the fundamental necessity of conserving available supplies by the exercise of the maximum economy. The effect of the operation during the war of strict discipline in national interests has rendered easier the acceptance of the doctrines of economy whatever the direction in which they are urged, and has made even the most retrogressive of men receptive of suggestions to this end.

Many engineers have now become familiar with the leading principles of internal combustion, and more Diesel work has been undertaken at home within the last few years, due to submarine naval requirements, than in any previous period. Many of the salient points are now appreciated, and growing interest is stimulated and met by the technical literature increasingly available.

Recent experience with the most modern and econo-mical steam installations applicable to merchantmen of average speed—the steam turbine and double-reduction gearing—has demonstrated clearly that the step from single to double reduction is not one of mere multipli-cation. New factors have been introduced and different values must be given to the various forces in operation. A complete solution, whether dependant upon a com-bination of all or principally upon a few of the many variables will no doubt early be found. The large number of factors entering into this question is sufficient alone to suggest its nature. The most important of these are lubrication, alignment of shafts, coincidence of helical angles, material and design of inter-meshing teeth, pressure and rubbing velocity between teeth, torsional vibrations, all of which play their parts. The present position, however, is such as to give to the Diesel engine a greater prominence than it might otherwise have achieved, in spite of the somewhat retrograde step from purely rotary to reciprocating motion.

The past record of the oil engine at sea shows in a striking manner the relative success of the four-cycle principle applied to single-acting engines. Table I of representative Diesel ships serves only to indicate a few of the notable vessels which have been produced. A number of these have, unfortunately, been lost during the war. Whilst out of the 34 one-half are fitted with two-cycle engines, these are mostly isolated cases. The four-cycle engined ships included are generally more than usually interesting units of fleets of considerable size and importance; of one type of four-cycle slow-running engine alone 122,000 i.h.p. are at sea.

In using the figures taken from publications as given in this table, and in subsequent data, it must be empha-sised that the majority of the engines are rated at power higher than can be consistently and continuously sustained at sea, and particularly is this qualification necessary when considering the figures relating to two-cycle machinery.

Experience during the war with submarines also showed the four-cycle engine in favourable light. Where reduction of weight, compactness, maximum power per unit volume of ship occupied by internal-combustion machinery were the chief considerations, the four-cycle principle was found fully to meet the requirements. In Germany the two-cycle engine was most favoured for marine work prior to 1914, but for submarine pro-pulsion during the war this system was gradually dropped. Ultimately, by far the larger number of German sub-marines and all having the highest power per unit had four-cycle engines. In our own navy the four-cycle principle was almost exclusively adhered to. Table II gives some of the leading characteristics of high-powered submarine engines.

The present position reflects clearly the finding of past performance, and an analysis of the marine Diesel machinery under construction in all engineering countries is given in Appendix I. Eighty-four per cent. of the ships are twin-screw, and over 80 per cent. of the total number of marine engines and horse-power is of the four-stroke cycle type. In Britain the two-cycle is more favoured than elsewhere.

The most important of the problems of design are common to both two and four-cycle engines, and the first concerns the injection of the fuel into the working cylinder. The exact quantity of fuel, at a pressure sufficient to ensure injection, must be measured out by the pump and spread in some 30 deg. of revolution as widely as possible into the combustion space, in a sufficiently finely-divided state to ensure rapid ignition and satisfactory combustion. Chiefly in this direction of improving distribution of the fuel in the combustion chamber can increased economy be sought.

There are two alternative methods of spraying; one by means of compressed air, the other by injecting the fuel at a high pressure known as the solid-injection system. The utilisation of compressed air is most general. So far as marine installations are concerned, the principle advantage of the solid-injection method, where compressed air is not used to assist injection, and is only required for supplying manœuvring power, is that the compressors are not a part of the main pro-pelling engine and do not require to run continuously at sea. Moreover, the air-compressing plant, where solid injection is adopted, can be reduced by from 40 per cent. to 50 per cent. in capacity.

Reliability with air compressors delivering at 850 lb. to 1,000 lb. per square inch has now reached a high level, the leading factors towards this end being generally appreciated, and air-compressor problems rated at their full value. Multi-staging is essential, and compression to 1,000 lb. per square inch should be carried out in not less than three stages, so proportioned that no undue ratio of compression and consequent temperature can occur in any stage. Particularly should the first or low-pressure compression be minimised. Such rises of temperature as are inevitable with compression should be reduced by efficient cooling of the air during com-pression and by the installation of intercoolers and after-coolers to reduce to atmospheric whatever temperature remains after compression. Removal of moisture from the air should be facilitated. Every effort in design should be made to ensure that the compressor valves and springs can be easily removed and replaced.

It is not to be inferred in any way that finality has been reached in compressor design or in methods of injection. In regard to the former a better means for removing oil and moisture from the air is required, and in respect of injection a suitable valve should be produced which, whilst requiring compressed-air spray for full power and maximum efficiency, can still operate satis-factorily at reduced power without the medium or assistance of compressed air.

The other fundamental of injection, the measuring of the oil fuel, involves the most delicate apparatus associated with the Diesel oil engine—the fuel injection pumps and controlling gear. The system of having

* Paper read before the Institution of Engineers and Shipbuilders in Scotland, October 19, 1920.

## TABLE I.—NOTABLE DIESEL SHIPS.

| Date. | Name of Vessel. | Dimensions. | | | Makers of Machinery. | Type of Engine. | Single or Twin. | Cycle. | I.H.P. per Engine. | B.H.P. per Engine. | No. of Cylinders per Engine. | B.H.P. per Cylinder. | Diameter of Cylinders. | Stroke. | Ratio, Stroke / Bore. | R.P.M. | Piston Speed. | M.E.P. on B.H.P. Basis. | M.E.P. on I.H.P. Basis. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | length. ft. | beam. ft. | depth. ft. | | | | | | | | | in. | in. | | | ft. per min. | | |
| 1910 | Vulcanus | 1,900 dispt. | 208 | 37½ | 13 | Werkspoor | Werkspoor | Single | 4 S.A. | 490 | 390 | 6 | 65 | 15½ | 23½ | 1·5 | 140 | 550 | 79·0 | 99·0 |
| 1912 | Selandia | 10,000 dispt. | 386 | 53 | 30 | Burmeister and Wain | Burmeister and Wain | Twin | 4 S.A. | 1,250 | 1,050 | 8 | 130 | 20½ | 28½ | 1·38 | 140 | 670 | 75·0 | 89·8 |
| 1912 | Jutlandia | 10,000 dispt. | 386 | 53 | 30 | Barclay Curle | Burmeister and Wain | Twin | 4 S.A. | 1,250 | 1,050 | 8 | 130 | 20½ | 28½ | 1·38 | 140 | 670 | 75·0 | 89·8 |
| 1912 | Monte Penedo | 6,500 dispt. | 350 | 50 | 27 | Sulzer | Sulzer | Twin | 2 S.A. | 1,200 | 850 | 4 | 212 | 18½ | 26½ | 1·44 | 160 | 715 | 78·0 | 103·0 |
| 1912 | Juno | 4,300 dispt. | 250 | 45 | 28 | Werkspoor | Werkspoor | Single | 4 S.A. | 1,460 | 1,100 | 6 | 183 | 21½ | 30½ | 1·87 | 125 | 820 | 84·0 | 111·0 |
| 1913 | Siam | 13,200 dispt. | 410 | 55 | 30½ | Burmeister and Wain | Burmeister and Wain | Twin | 4 S.A. | 1,580 | 1,350 | 8 | 169 | 23½ | 31½ | 1·34 | 125 | 660 | 77·0 | 90·0 |
| 1913 | Wotan | 7,960 dw. | 404 | 52½ | 29½ | Rotherstieg | Carels | Single | 2 S.A. | 2,100 | 1,650 | 6 | 275 | 23½ | 43½ | 1·83 | 90 | 650 | 64·0 | 81·5 |
| 1913 | Hagen and Loki | 7,900 dw. | 400 | 53 | 32½ | Krupp | Krupp | Twin | 2 S.A. | 1,600 | 1,200 | 6 | 200 | 18½ | 31½ | 1·69 | 135 | 720 | 66·0 | 88·0 |
| 1913 | Arum | 5,600 dispt. | 360 | 47 | 27 | Swan Hunter | Swan Hunter "Neptune" type | Twin | 2 S.A. | 850 | 600 | 4 | 150 | 17½* | 33 | 1·91 | 120 | 660 | 64·0 | 90·5 |
| 1914 | Fionia | 7,000 dw. | 395 | 56 | 30 | Burmeister and Wain | Burmeister and Wain | Twin | 4 S.A. | 2,140 | 1,600 | 6 | 286 | 29½ | 43½ | 1·49 | 100 | 720 | 74·0 | 99·0 |
| 1916* | Abelia | 5,600 dispt. | 360 | 47 | 27 | Wallsend Slipway and Engineering Co. | Maschinen-Fabrik, &c. (M.A.N.) | Twin | 2 S.A. | 850 | 600 | 4 | 150 | 17½ | 33 | 1·91 | 120 | 660 | 64·0 | 90·5 |
| 1916 | Trefoil | 4,510 dispt. | 280 | 39 | 23½ | Vickers | Vickers | Twin | 4 S.A. | 1,000 | 750 | 8 | 94 | 17 | 27 | 1·59 | 150 | 675 | 81·0 | 108·0 |
| 1916 | Hamlet | 10,050 dispt. | 360 | 56 | 29½ | Atlas Diesel, Sweden | Polar | Twin | 2 S.A. | 2,300 | 1,650 | 6 | 275 | 24 | 36 | 1·5 | 120 | 720 | 67·0 | 93·5 |
| 1918 | Ansaldo San Giorgio I | 8,100 dw. | 378 | 50½ | 30½ | Ansaldo San Giorgio | F.I.A.T. (now Ansaldo San Giorgio) | Twin | 2 S.A. | 1,450 | 1,100 | 4 | 275 | 24½ | 35½ | 1·48 | 100 | 590 | 64·0 | 84·5 |
| 1919 | Glenapp | 19,000 dispt. | 450 | 55½ | 36½ | Harland and Wolff | Burmeister and Wain | Twin | 4 S.A. | 3,200 | 2,625 | 8 | 328 | 30 | 43½ | 1·44 | 115 | 830 | 74·0 | 90·5 |
| 1920 | Afrika | 18,600 dispt. | 445 | 60 | 42 | Burmeister and Wain | Burmeister and Wain | Twin | 4 S.A. | 3,250 | 1,700* | 6 | 283 | 29½ | 45½ | 1·55 | 115 | 865 | 65·0 | 86·0 |
| 1920 | Glengyle | 19,000 dispt. | 503 | 62 | 27½ | Harland and Wolff | Burmeister and Wain | Twin | 4 S.A. | 3,200 | 2,625 | 8 | 328 | 29½ | 45½ | 1·55 | 115 | 865 | 75·0 | 91·5 |
| 1920 | Fritz | 4,000 dw. | 331 | 44½ | — | Blohm and Voss | M.A.N. | Twin | 2 D.A. | 1,250* | 850 | 2 | 283 | 18½ | 28 | 1·48 | 110 | 515 | 65·0 | 95·5 |
| 1920 | Maumee | 15,000 dispt. | 453 | 56 | 26 | New York Naval Yard | M.A.N. | Twin | 2 S.A. | 3,200 | 2,500 | 6 | 416 | 25½ | 37½ | 1·48 | 130 | 810 | 69·0 | 88·0 |
| 1920 | Cubore | 17,000 dispt. | 450 | 57 | 37 | Bethleham Steel Co. | — | Single | 2 S.A. | 3,900 | 2,700 | 6 | 450 | 25½ | 48 | 1·87 | 100 | 800 | 73·0 | 105·0 |
| 1920 | Zoppot | 22,000 dispt | 525½ | 66½ | 33½ | Krupp | Krupp | Twin | 2 S.A. | 2,000 | 1,400 | 6 | 233 | 22½ | 39½ | 1·73 | 106 | 695 | 55·0 | 79·0 |
| 1920 | Salerno | 6,500 dw. | 375 | 51 | 34 | Werkspoor | Werkspoor | Twin | 4 S.A. | 1,400 | 1,050 | 6 | 175 | 22 | 39½ | 1·78 | 125 | 820 | 74·0 | 98·5 |
| 1920 | Narragansett | 14,000 dispt. | 425 | 56½ | 38 | Vickers | Vickers | Twin | 4 S.A. | 1,620 | 1,250 | 6 | 208 | 24½ | 39 | 1·59 | 118 | 767 | 76·0 | 99·0 |
| 1920 | Fullagar | 500 dw. | 150 | 23½ | 11½ | Cammell Laird | Fullagar | Single | 2 O.P | 660* | 500 | 4 | 125 | 14 | 20×2 | 1·43 | 110 | 367 | 73·5 | 92·0 |

* Approximate. S.A. = Single-acting. D.A. = Double-acting. O.P. = Opposed piston.

## TABLE II.—Submarine Engines.

| Makers of Engine. | Two or Four-Cycle. | B.H.P. per Engine. | No. of Cylinders. | B.H.P. per Cylinder. | Diam. of Cylinder. | Stroke. | Ratio Stroke Bore. | R.P.M. | Piston Speed. | M.E.P. on B.H.P. Basis. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | in. | in. | | | ft. per min. | |
| Vickers | 4 single-acting | 1,200 | 12 | 100 | 14½ | 15 | 1·035 | 380 | 950 | 84 |
| Schneider | 2 single-acting | 1,600 | 8 | 200 | 16½ | 17½ | 1·1 | 330 | 975 | 67 |
| Krupp | 2 single-acting | 1,600 | 6 | 266 | — | — | — | 350 | — | — |
| M.A.N. | 4 single-acting | 1,750 | 6 | 290 | 20·8 | 20·8 | 1·0 | 380 | 1,315 | 85 |
| M.A.N. | 4 single-acting | 3,000 | 10 | 300 | 20·8 | 20·8 | 1·0 | 380 | 1,350 | 88 |
| Toni | 4 single-acting | 1,500 | 8 | 188 | 18½ | 23½ | 1·27 | 300 | 1,180 | 79 |

## TABLE III.—Experimental Engines.

| Makers or Owners. | Two- or Four-Cycle. | B.H.P. per Engine. | No. of Cylinders. | B.H.P. per Cylinder. | Diam. of Cylinder. | Stroke. | Ratio Stroke Bore. | R.P.M. | Piston Speed. | M.E.P. on B.H.P. Basis. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | in. | in. | | | ft. per min. | |
| Sulzer | 2 single-acting | 1,600 | 1 | 1,600 | 39½* | 43½* | 1·1 | 115 | 1,000 | 103 |
| Krupp | 2 double-acting | 2,000 | 1 | 2,000 | — | — | — | — | — | — |
| M.A.N. | 2 double-acting | 4,000 | 3 | 2,000 | 31½ | 41½ | 1·32 | 160 | 1,110 | 76 |
| Carels | 2 single-acting | 1,000 | 1 | 1,000 | 30* | 30* | 1·2 | 150 | 900 | 103 |
| Doxford | 2 opposed piston | 500 | 1 | 500 | 19½ | 29½×2 | 1·49 | 120 | 590 | 91 |
| Still | 2 double-acting | 350 | 1 | 350 | 22 | 36 | 1·63 | 120 | 720 | Oil, 63<br>Steam, 33 |
| Admiralty | 4 single-acting | 300 | 1 | 300 | 20 | 20 | 1·0 | 360 | 1,300 | —<br>96<br>97 |

* Approximate

## TABLE IV.—Comparison of Running Costs of Diesel Ships and Steam Ships of 1,000 Brake Horse-Power.

| | Single-Screw, Diesel, 1,000 B.H.P. | Single-Screw, Double-Reduction Geared, 1,000 S.H.P. | | Single-Screw, Reciprocating, 1,200 I.H.P. | |
|---|---|---|---|---|---|
| | | Coal. | Oil. | Coal. | Oil. |
| Fuel, pounds per horse-power per hour | 0·45 | 1·5 | 1·1 | 1·95 | 1·4 |
| Consumption, tons per day | 4·82 | 16·1 | 11·8 | 25·0 | 18·0 |
| Consumption, tons per 30 days | 145 | 483 | 354 | 750 | 540 |
| Price of fuel per ton | 11l. | 5l. | 10l. | 5l. | 10l. |
| Cost of fuel per 30 days | 1,595l. | 2,415l. | 3,540l. | 3,750l. | 5,400l. |
| Lubricating oil consumption, gallons per day | 10 | 2 | 2 | 3 | 3 |
| Lubricating oil, cost per gallon | 5s. | 5s. | 5s. | 5s. | 5s. |
| Lubricating oil, cost per 30 days | 75l. | 15l. | 15l. | 22l. 10s. | 22l. 10s. |
| *Personnel*— | | | | | |
| Chief engineer | 1 | 1 | 1 | 1 | 1 |
| Assistant engineers | 3 | 2 | 2 | 2 | 2 |
| Greasers | 3 | 3 | 3 | 3 | 3 |
| Firemen | — | 3 | 3 | 3 | 3 |
| Trimmers | — | 3 | — | 3 | — |
| Donkeyman | 1 | 1 | 1 | 1 | 1 |
| Electrician | 1 | — | — | — | — |
| Total engine-room staff | 9 | 13 | 10 | 13 | 10 |
| Total wages, 30 days | 191l. | 224l. 10s. | 195l. | 224l. 10s. | 195l. |
| Total keep per 30 days, at 7s. per day | 94l. 10s. | 136l. 10s. | 105l. | 136l. 10s. | 105l. |
| Total wages, fuel, oil and keep for 30 days | 1,955l. 10s. | 2,791l. | 3,855l. | 4,135l. 10s. | 5,729l. 10s. |
| Ratio | 1 | 1·44 | 1·97 | 2·12 | 2·93 |
| Net saving per annum of 200 days' sailing, Diesel over steam | — | 5,570l. | 12,650l. | 14,520l. | 25,250l. |

Note.—In addition to the above, the following savings are effected. Fuelling costs, less demurrage, additional cargo capacity, less accommodation for engine-room staff, no stand-by losses, less cleaning ship, higher average speed in a sea-way, reduced fuelling appliances required, &c.

one pump per cylinder is now almost universal for marine work (excepting where solid injection is used), and only in this way can the maximum security against a large percentage of overcharge and overload in one or more of the cylinders be obtained. These individual pumps therefore, become of relatively small size. Even with separate pumps, continual care and intelligent supervision must be exercised to ensure that the deliveries from the pumps are maintained equal, lest one or more cylinders should be overloaded to counteract the effect of diminished deliveries from defectively working pumps. Means are now generally provided whereby any pump can be cut out and overhauled whilst the remainder are in operation.

The Diesel engine remains a heavy and expensive prime mover in comparison with its steam rivals. Even with the progress made in design within the last six years, it can definitely be stated that there has been generally an increase in the weight and the space occupied by the slow-speed Diesel engine per horse-power developed continuously. The factors opposed to a reduction of these disabilities and rendering difficult the path toward the higher powers now desired, are the temperature gradient through the metal surrounding the combustion chamber and the fact that the major portion of the material of the engine is only utilised for a small fraction of the running time. The former refers particularly to the two-cycle, and the latter to the four-cycle engine, where three-quarters of the running time is idle so far as power output is concerned. Moreover, of the one power stroke per 2 revolutions, only one-half of this stroke, or 12·5 per cent. of the cycle stresses the parts of the engine comparably with their strength and scantlings.

The unique economies possible by the adoption of the principle of internal combustion are only gained at the expense of forgoing all the many advantages derived from using the most flexible known power-conveying medium, steam.

To appreciate the type of stressing to which the main parts of a Diesel engine are subject comparison may be made with a steam engine of normal design and of equal power output. The maximum normal load with the oil engine is more than five times as great, and, furthermore, the rate of application of this main load is increased 10 times.* With internal combustion the normal stresses are liable to sudden increases calling for a larger factor of safety, and design questions relating to the main parts of the engine must be considered strictly in this light.

In regard to the temperature gradient and the stresses so incurred, data are lacking; but, so far as they are available, they go definitely to prove that the four-stroke cycle engine has distinct advantages. In Appendix II. calculations are given to show that the temperature gradient through the metal of a four-cycle cylinder liner and through the furnace of a cylindrical marine boiler are substantially equal. In the former the stressing is intermittent, and in the latter relatively steady. The stresses consequent upon this temperature gradient are half as high again in the case of the boiler furnace, due to the higher coefficient of expansion and modulus of elasticity of steel as compared with cast-iron. With the cylinder liner the transmission of heat is a subsidiary function to the more important duties of guiding the power piston and maintaining a suitable surface to permit piston-ring gastightness with minimum friction. The simple design of liner adopted up to the present with all but a few exceptions, cannot be approved on

* Proc. of the Junior Institution of Engineers, May, 1914. "High Power Diesel Engines; Their Development for Marine Service."

theoretical grounds. To obtain a minimum value for the combined stress consequent upon temperature gradient through the metal and internal pressure, a ribbed and built-up form of construction must be adopted. This can very simply be accomplished, as is sometimes the case, with the four-cycle engine, but imposes greater difficulties in the case of the two-cycle, where exhaust and scavenging ports have to be accommodated in the cylinder. Computation of the high stresses with the two-cycle cylinder in way of scavenging air-inlet and main exhaust ports is extremely difficult. These are bound to be very considerable in view of the high velocity of the exhaust gases and the consequent high rate of heat transmission from these gases to the walls, and are further intensified by cooling and distorting effect of the entering scavenging air with the normal two-cycle design.

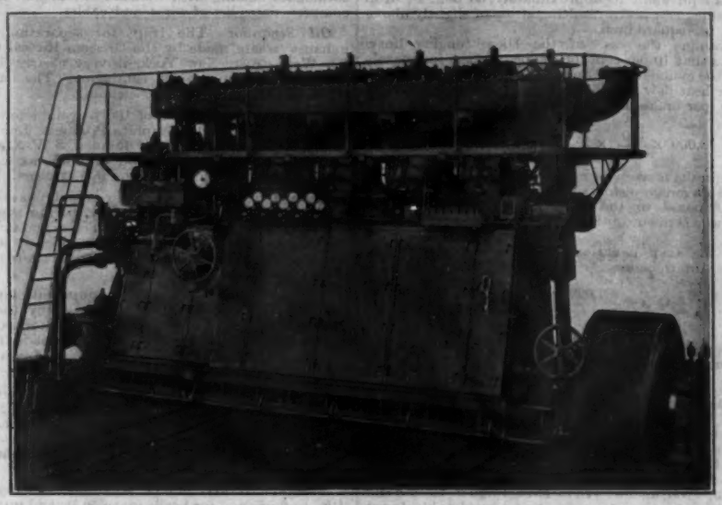


Fig. 1. Four-Cylinder Tosi Marine Diesel Engine, 400 B.H.P.

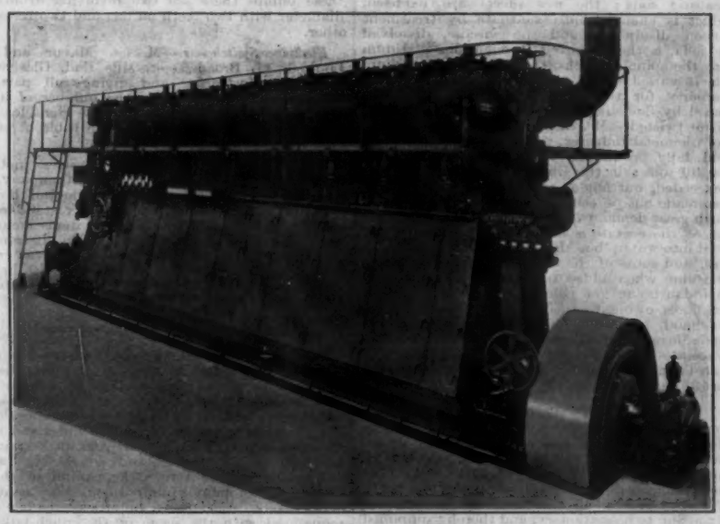


Fig. 2. Eight-Cylinder Tosi Marine Diesel Engine, 800 B.H.P.

TABLE V.—Comparison of Running Costs of Diesel Ships and Steam Ships of 2,400 Brake Horse-Power.

| | Twin-Screw, Diesel, 2,400 B.H.P. | Single-Screw, Double-Reduction Geared, 2,400 S.H.P. | | Single-Screw, Reciprocating, 2,800 I.H.P. | |
|---|---|---|---|---|---|
| | | Coal. | Oil. | Coal. | Oil. |
| Fuel, pounds per horse-power per hour | 0·45 | 1·5 | 1·1 | 1·75 | 1·25 |
| Consumption, tons per day | 11·6 | 38·6 | 28·3 | 52·5 | 37·5 |
| Consumption, tons per 30 days | 348 | 1,158 | 849 | 1,575 | 1,125 |
| Price of fuel per ton | 11l. | 5l. | 10l. | 5l. | 10l. |
| Cost of fuel per 30 days | 3,828l. | 5,790l. | 8,490l. | 7,875l. | 11,250l. |
| Lubricating oil, consumption, gallons per day | 21 | 3 | 3 | 5 | 5 |
| Lubricating oil, cost per gallon | 5s. | 5s. | 5s. | 5s. | 5s. |
| Lubricating oil, cost per 30 days | 157l. 10s. | 22l. 10s. | 22l. 10s. | 37l. 10s. | 37 . 10s. |
| *Personnel*— | | | | | |
| Chief engineer | 1 | 1 | 1 | 1 | 1 |
| Assistant engineers | 6 | 3 | 3 | 3 | 3 |
| Greasers | 3 | 3 | 3 | 3 | 3 |
| Firemen | — | 9 | 6 | 9 | 6 |
| Trimmers | — | 4 | — | 4 | — |
| Donkeyman | 1 | 1 | 1 | 1 | 1 |
| Electrician | 1 | — | — | — | — |
| Total engine-room staff | 12 | 21 | 14 | 21 | 14 |
| Total wages, 30 days | 252l. 10s. | 380l. 10s. | 265l. | 380l. 10s. | 265l. |
| Total keep per 30 days, at 7s. per day | 126l. | 220l. 10s. | 147l. | 220l. 10s. | 147. |
| Total wages, fuel, oil and keep for 30 days | 4,364l. | 6,413l. 10s. | 8,924l. 10s. | 8,513l. 10s. | 11,699l. 10s. |
| Ratio | 1 | 1·47 | 2·04 | 1·95 | 2·68 |
| Net saving per annum of 200 days' sailing, Diesel over steam | — | 13,650l. | 30,390l. | 27,645l. | 48,850l. |

Notes.—In addition to the above, the following savings are effected. Fuelling costs, less demurrage, additional cargo capacity, less accommodation for engine room staff, no stand-by losses, less cleaning ship, higher average speed in a sea-way, reduced fuelling appliances required, &c.

Table VI.—*Cost of Fuel Oil and Coal at Principal Ports, July, 1920.*

| Port. | Fuel Oil per Ton. | Coal per Ton. |
|---|---|---|
| | s. d. | s. d. |
| Alexandria | 230 0 | 186 0 to 200 |
| Adelaide | 180 0 | 40 0 |
| Batavia | 150 0 | 127 6 |
| Bombay | 150 0 | 45 0 |
| Buenos Aires | 265 0 | 170 0 |
| California | 62 0 to 92 0 | 69 0 |
| Christiania | 224 0 | 210 0 |
| Calcutta | 250 0 | 25 0 |
| Cape Town | 220 0 | 46 9 Transvaal. |
| Colombo | 150 0 | 102 6 |
| Curaeao | 80 0 | 125 0 |
| Glasgow | 250 0 | 115 0 Welsh. |
| Hong Kong | 150 0 | 115 0 Welsh. |
| Havana | 142 6 | 125 0 |
| Karachi | 150 0 | 45 0 |
| London | 250 0 | 115 0 Welsh. |
| Liverpool | 250 0 | 115 0 Welsh. |
| Lisbon | 250 0 | 160 0 |
| Madras | 150 0 | 42 0 |
| Melbourne | 180 0 | 35 0 |
| New Orleans | 58 2 | 40 0 to 60 0 |
| New York | 47 6 | 55 0 to 68 0 |
| Palembang | 125 0 | 127 0 |
| Pensacola | 80 0 | 42 0 |
| Port Said | 250 0 | 186 6 |
| Panama | 75 0 | 125 0 |
| Rotterdam | 220 0 | 160 0 |
| Rio de Janeiro | 250 0 | 185 0 |
| St. Thomas | 160 0 | 124 0 |
| Sydney | 175 0 | 21 3 |

Average price per ton: Coal = 104s.; fuel oil = 191s.

For a better utilisation of materials than is achieved with the four-cycle engine, the two-cycle single-acting, the four-cycle double-acting, the opposed pistons construction, the two-cycle double-acting principles or the combined effect of oil and steam as with the "Still" engine are put forward. However attractive may be the mechanical arrangements so facilitated, the Diesel oil engine is a complicated machine highly loaded and stressed by high-pressure combustion within the cylinder, and short cuts to achieve reduction in space weight and cost, will only be fruitful in so far as first principles and fundamentals more especially in respect of rate of heat transmission, are not violated.

The foregoing conditions of design of the Diesel engine prevent it from being a cheap and light prime mover. Increased experience, better materials, more efficient utilisation of such masses as are required to cope with the pressures of the cycle, together with standardisation, will in due course effect a reduction in these disabilities. As an example of the possibilities of constructing engines, of varying power with the same unit cylinders, Figs. 1 and 2 show two of three sets of four, six and eight cylinders giving respectively 400 brake horse-power, 600 brake horse-power and 800 brake horse-power respectively.

At present the cost can be stated to be from 25 per cent. to 33 per cent. more than for a steam plant, depending on the type of auxiliaries applied to the oil-engined ship, and whether comparison is made with reciprocating or double-reduction turbine steam machinery. This higher cost is minimised in effect by the greater cargo-carrying capacity sometimes possible by the adoption of oil engines, or alternatively by the fact that a smaller Diesel-engined ship serves to give earning capacity equal to a steamer. The economy of operation possible with the oil engine is such that, granted reliable performance, the extra cost is speedily balanced by the increased profits obtainable. Tables IV and V indicate in two cases the nature of the comparison. The total saving for 200 days' sailing per annum by installing Diesel instead of steam machinery is given for wages and keep, fuel and oil costs, in the case of a single-screw ship of 1,000 brake horse-power, and also a ship of 2,400 brake horse-power; twin-screw in the case of Diesel engines and single-screw in the case of steam. No estimation has been made regarding the other savings generally possible, the most important of which is additional cargo capacity, no stand-by losses, and higher average speed, more particularly when the oil is compared with the coal-fired ships. The figures, however, for the savings in fuel, lubricating oil, wages and keep are, it will be admitted, sufficiently attractive to merit close attention by shipowners to the Diesel system of propulsion, when full comparisons can readily be made to meet the specific case of any particular type of ship or trade.

The prices of oil fuel and coal at various ports given in Table VI may be referred to.

That after ten years of experience, keeping in view the last five years of intensive service, reliability can be obtained with the Diesel engine will not be gainsaid. The position of this new prime mover is not yet, however, sufficiently secure for short cuts towards the lightening or cheapening of the engine to be undertaken without the most careful consideration. The available knowledge demands that oil engines shall be rated at a moderate power-output per unit of swept cylinder volume with the consequent low-temperature gradient through, and stresses in the metal exposed to combustion temperature. Ample strength and rigidity must be given to those parts

that are stressed by the pressure of the cycle, and a high quality of workmanship is essential for all the principal units. So long as labour conditions do not very appreciably change, the Diesel oil engine will increase rapidly in importance, with the full realisation of the enormous advantages of liquid fuel as a marine combustible. Satisfactory distribution of fuel throughout the world seems assured, and any future shortage will first affect those plants less able to compete in regard to economy of consumption of liquid fuel. Powers up to 6,000 brake horse-power or even 8,000 brake horse-power per ship with twin screws (500 brake horse-power per cylinder) can be looked for in the very near future, and gradual increases will take place successfully by short steps consolidating each advance as gained, before proceeding to the attainment of higher outputs.

Table III gives a few particulars of the largest single-unit and experimental engines built up to date. Below 800 brake horse-power to 1,000 brake horse-power per cylinder, it can now definitely be stated that there are no limiting conditions. With increasing size of cylinder altered methods of construction will be called for to minimise the effect of temperature gradient, and may even be compelled by marine requirements in order to reduce size and weight.

Under the entirely new conditions now operating it is pleasing to reflect that at home there are under construction a larger variety of types of marine oil engines than in any other country, indicating an enterprising and progressive policy of determined trial. This is in strong contrast to the apathy with which we were charged before the war. Experience in due course with these engines will go far to enable relative values to be given to various systems and types of construction. In time, a few may be eliminated, as has been the case with other prime movers, but the majority will remain until gradual development and increased application enables a higher plane of performance to be reached when the issue will become narrowed down.

In the future the claims of the Diesel-electric system of propulsion will receive much more attention than hitherto, and this may prove the most secure path towards high power. Whatever the merits of steam-electric marine installations, the case for the Diesel-electric, so far as the mercantile marine is concerned, is much stronger.

The longed-for internal-combustion turbine does not yet appear on the horizon. The relative inefficiency of high-pressure turbo-compressors, the losses consequent upon the transference of the working medium from the compressor to the turbine, and the difficulties experienced with available materials when subjected continuously to the high temperatures necessary for economy, have so far been insuperable barriers to development.

What the future holds in store cannot be forecasted. Sufficient for the moment is the fact that there are many known problems with internal-combustion engines to which only at best comparatively clumsy solutions have so far been found. Improvement of the present state of this science calls for the highest efforts of engineering skill, and the time has arrived when energy and enterprise expended in such a direction may look expectantly for the just reward of a broadening application to marine work.

## APPENDIX I.

An analysis of Diesel marine installations under construction in September, 1920.

The following figures are based on the published particulars of 184 ships and their machinery.

1. The total tonnage expressed as deadweight capacity is 1,263,000 tons, divided as follows :—

Two-cycle = 208,000—
Twin-screw, 144,000 tons deadweight.
Single-screw, 64,000 tons deadweight.
Four-cycle = 1,055,000—
Twin-screw, 1,005,000 tons deadweight.
Single-screw, 50,000 tons deadweight.

2. The total brake horse-power is 405,000, of which 326,500 is four-cycle, and 78,500 two-cycle. The indicated horse-power is in approximately the same ratio.

3. Of the 325 engines comprised in the above totals, 275 are four-cycle and 50 are two-cycle.

4. The average brake horse-power per engine is 1,240, the four-cycle being 1,190 and the two-cycle 1,570. The average brake horse-power per cylinder is 210 ; in the case of the four-cycle 194, and the two-cycle 309.

## APPENDIX II.

Comparison of the Temperature Gradient and Stress in a Cylindrical Boiler-Furnace and a Diesel Engine Cylindrical Liner.

Estimation of the temperature-drop through the metal of a cylindrical boiler furnace.

Assume an evaporation from the furnace crown of 15 lb. of water per hour per square foot of heating surface.

The number of British thermal units required to raise 1 lb. of water from a feed temperature of 191 deg. to 391 deg. F. (temperature for a pressure of 200 lb. per square inch).

The total British thermal units = 200 + 839 = 1,039.

British thermal units per square foot of furnace = 1,039 × 15 = 15,600 British thermal units per square foot.

The temperature drop to convey this heat-flow through a furnace shell of ½ in. thickness is

$$T_1 - T_2 = \frac{Q \times t}{K}$$

where $t$ is thickness in feet, and K is the conductivity of the steel plate—

$$T_1 - T_2 = \frac{15{,}600 \times \frac{0{\cdot}625}{12}}{26} = 31 \text{ deg. F.}$$

This is equivalent to approximately 30 deg. F. drop per inch thickness, and a resulting stress of slightly above 3,000 lb. per square inch.

To examine the case of the Diesel engine liner. Assuming that 10 per cent. of the heat of the fuel passes through the cylinder liner, and that the ratio of maximum to mean heat-flow is 2·5 to 1, with a consumption of 0·425 lb. per brake horse-power per hour, the heat-flow becomes,

$$0{\cdot}425 \times 18{,}000 \times \frac{10}{100} \times 2{\cdot}5 = 1{,}920 \text{ British thermal}$$

units per brake horse-power per hour.

With an average piston speed a fair allowance of liner surface exposed to the combustion gases per brake horse-power is given by 9 brake horse-power per square foot.

Using the same equation as above and considering a liner of 1 in. thickness—

$$T_1 - T_2 = \frac{Q \times t}{k} = \frac{1{,}920 \times 9 \times \frac{1}{12}}{20} = 55 \text{ deg. F.}$$

per inch thickness and a stress of about 2,000 lb. per square inch.

---

The Artificial Silk Industry.—The artificial silk industry has expanded greatly during the war. The process used in this country is not the nitro-process of Chardonnet, nor the German cuprammonium process, but the British viscose process, which starts from wood pulp, and not from cotton. Though wood pulp now costs 100*l.* a ton, against 12*l.* in 1914, English viscose silk is at present put on the market at considerably lower prices than other artificial silks. The pulp, is converted into alkali cellulose by being steeped in strong caustic soda ; the wet sheets are oxidised, the product is changed into xanthate by treatment with carbon disulphide, and the viscose, dissolved in dilute soda, is then squirted through fine platinum tubes into the spinning baths, the coagulating medium of which is varied so as to secure high lustre and dyeing affinity for the silk fibre. When the tubes are replaced by fine slits, "ribbon straw" is obtained which is not twisted. Mr. L. P. Wilson (Journal of the Society of Chemical Industry, August 16 last) estimates the actual daily production of artificial silk in Great Britain at 10 tons ; in the United States this figure is greatly exceeded, but not on the Continent. Artificial silk is also made out of cellulose acetate, which is not now in such great demand for aeroplane dopes as during the war. As the acetate is not soluble in water, it can be squirted into water, but the acetate fibre only takes basic dyes, and some of the organic compounds which soften the fibre when added to the water, also decompose the indanthrone vat colours, which are popular on other fibres owing to their superior fastness. On the other hand, acetate cellulose is a good material for electric insulation. These statements concerning cellulose-acetate silk were criticised by Mr. Briggs, of the British Cellulose Company (see the Journal quoted of August 31 and September 15).

---

Einstein's Theory of Relativity.—The significance or relativity problem was well characterised in a non-mathematical public lecture, delivered on October 11, at University College by Dr. G. B. Jeffery, M.A. The system of Ptolomæus, he pointed out, made the Earth the stationary centre of the universe. Copernicus assumed the Sun to be stationary, and thereby simplified the mathematical calculations without subverting the aspect of the problem. Later it was found that the Sun was moving, and that the fixed stars likewise had their own motion and hence could not serve as a stationary frame of reference in space. Meanwhile the ether had been accepted as pervading the universe ; the Michelson-Morley experiment proved that we have no means of deciding whether or not we are moving with respect to the other ; that frame of reference failed as well, therefore. Practically we were confronted with the problem when we tried to synchronise two clocks one of which was moving, by signals travelling between the two clocks. For an observer outside, the moments of arrival of the signals would not be the same as for the observer travelling with the clock. Similar considerations affected measurements of lengths in the direction of motion and in other directions. Again, if we imagined two people travelling in opposite directions carrying apparatus such that electric sparks passed on their meeting, each of the two would imagine that the spherical electric wave produced by his spark would remain concentric to himself—which was impossible to any observer outside. Or if each observer were surrounded by a spherical mirror, the man travelling west would imagine that the western portion of the sphere was illuminated before the eastern portion. Passing to gravitation, Dr. Jeffery showed that the person surrounded by a gravitational field would be unable to say whether gravitation pulled him and things downward in accelerated motion, or whether he was being carried upward by an accelerating force. From this point of view the three crucial tests of the theory, viz., the movement of the perihelion of Mercury, the bending of a ray of light by gravitation, and the apparent shifting of the Fraunhofer lines in the Sun compared the spectrum lines of a terrestrial source, might be considered, as Dr. Jeffery proceeded to show. The arguments implied the insufficiency of Euclidean geometry to deal with these problems.

## CATALOGUES.

*Electrical Goods.*—The Sun Electrical Company, Limited, 120, Charing Cross-road, London, W.C. 2, send catalogues dealing with ironclad switchgear, and also a comprehensive list of wires and cables.

*Oil Separator.*—The trap for separating oil from exhaust steam made by the Griscom-Russell Company, 90, West-street, New York, is very clearly illustrated and described in a special catalogue. The baffle plates are easily withdrawable for cleaning.

*Graphite.*—A catalogue of the very numerous graphite products made by the Graphite Products, Limited, 218–220 Queen's-road, Battersea, London, S.W. 8, contains a carefully stated discussion on graphite as a lubricant which is worth attentive reading by engineers.

*Electric Motors.*—A catalogue of polyphase induction motors, of the squirrel-cage and slip ring types, which has been issued by Messrs. Bruce Peebles and Co., Limited Edinburgh, contains very full specifications, lists of ratings, and much useful explanatory matters relating to these machines.

*Electrical Equipment.*—The equipment supplied for the large aeroplane factory organised by the Crossley Motors, Limited, Heaton Chapel, near Stockport, during the war is described in a four-page sheet issued by the makers, the General Electric Company, Limited, Queen Victoria-street, London, E.C. 4.

*Electric Switches.*—Oil switches for controlling and protecting feeder circuits, transformers, &c., arranged for direct or remote operation, and with many combinations of trip mechanism, are the special subject of a catalogue received from Messrs. Johnson and Phillips, Limited, Charlton, London, S.E. 7.

*Pumps.*—Rotary pumps with outlets ranging from 1 in. to 6 in., and for heads up to 50 ft. and up to 100 ft., are shown in a circular issued by the No-Val Engineering Company, Limited, 7, Gordon-street, Bradford. In these pumps there are two revolving drums of equal diameter with two teeth on one and two recesses in the other.

*Electric Switchgear.*—Messrs. Mavor and Coulson, Limited, 47, Broad-street, Mile End, Glasgow, send a catalogue illustrating and giving full particulars of industrial switch gear. As the number of items dealt with in the catalogue is very considerable, we would suggest the inclusion of a concise table of contents in future editions.

*Hoistings.*—A catalogue of electric motor hoists received from the General Electric Company, Limited, Witton, Birmingham, shows a monorail hoist, either slung or self-travelling, made in six standard sizes to lift from 5 cwt. to 2 tons. Other items included are a worm-geared winch in twenty sizes to lift from 1½ cwts. to 45 cwts. ; a spur geared winch in seven sizes to lift from 5 cwt. to 60 cwt. ; a friction hoist in five sizes to lift from 3 cwt. to 20 cwt. ; and a capstan in four sizes to pull from 10 cwt. to 60 cwt.

---

Platinum Find in South Africa.—The report by Mr. Grindley Ferris on the big platinum discovery in the Cala district of Cape Colony is not yet available, says *The South African Mining and Engineering Journal*, but it is understood to be of a most favourable nature. The ore body is said to extend 13 miles and the values are extraordinarily high. The African Platinum Mines, Limited, are the owners, and several big Cape houses are behind the venture. The capital of the African Platinum Company, Limited, is, our contemporary understands, 150,000*l.* Inquiries made of those acquainted with the scene of the much-talked-of discoveries go to show that large areas occur carrying platinum in small quantities, in which are sectional zones of concentration. From these latter the samples giving the high assays that have been mentioned, i.e., up to 12 dwts. and 15 dwts., are taken. Enough has been proved to point to the possibility of the establishment of an important industry. The African Platinum Company have adopted the wise course of sending down Mr. J. R. Williams with adequate assay plant to test the ground as thoroughly as possible. It is of interest to note that in the Urals ore going 1½ dwts. platinum is profitably worked.

---

Removal of Boiler Ashes.—The removal of ashes from boiler grates is sometimes troublesome and costly. According to a paper read by Director Scholtes of the Hibernia Colliery, near Herne, Westphalia, before a meeting of the Union of Electricity Works at Goslar, last September, the water-flush system adopted in that colliery five years ago, has given general satisfaction. Their boiler-house contains 22 boilers, all in a row. The ashes fall into open conduits leading, with a fall of 1·7 per cent., to a common tank ; a centrifugal pump keeps the water, filtered through sieves, in circulation at the rate of 33 litres (about 8 gallons) per second. The tank has a capacity of 15 cub. m. The 100 tons of ashes settling in the tank per day are raised by a chain of buckets into a bunker from which they are delivered into railway trucks. The conduits are lined with stoneware plates from Mettlach, a district known for these products ; these plates have not required renewal so far, whilst sheet iron linings, at first tried, did not last more than two months. The system does not answer for bituminous lignite fuels which do not take up water readily. Such ashes are removed either by suction, when of dust consistency, or by chain-truck conveyors. Scholtes dealt with the problems in a general way.